POWER

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Accidents

DID you ever have an accident? And when it was over, did you think how easily it might have been averted?

They used to be called Acts of God, but now it is generally allowed that for every effect there is a natural cause, and that in many, if not most of the cases, the causes are sufficiently evident to be removable by ordinary human foresight and precaution.

The fellow who is habitually unlucky, who is perpetually in trouble, is the fellow who does not watch out sharply enough for these causes, or, if he is conscious of their existence, lets them go through procrastination or takes a chance to save himself trouble or avoid a shutdown.

An intelligent following up of some apparently insignificant signal of distress may lead one to the scene of a battle of molecules which, if left to fight itself out, might mean widespread disaster.

A little neglect of true craftsmanship in the making of a casting, a joint or a weld may mean a failure that will cost human life.

Of course there are misfortunes, the causes of which are so complex and mysterious that they cannot be foreseen, or, if they could, might not be capable of prevention.

But research and the growing control of man over the forces and processes of nature are doing much to mitigate the larger afflictions of the race through such things as flood and famine and pestilence.

It is the numerous little accidents, costly and destructive in the aggregate, that each can prevent or help to minimize through honest work, sound construction and careful, attentive operation.

F. R. Low

Clark Thread Co. Installs Pulverized-Fuel Equipment

THIS article describes a typical pulverized-coal installation for an industrial plant. Furnaces of 4,270 sq.ft. Stirling boilers remodeled to burn either pulverized coal or oil. Furnace volume increased from 850 to 2,550 cu.ft. Preparation plant is adjacent to point of unloading and coal is transported in pulverized form through a 5-in. pipe line (placed underground) a distance of 600 ft. to the boiler plant.

ALTHOUGH pulverized coal has been successfully applied to the firing of stationary boilers for many years, not until a few months ago, when two boilers were put into operation at the Clark Thread Co., Newark, N. J., was this method of firing introduced into the Metropolitan area.

The plant of the Clark Thread Co., manufacturers of spool and fine embroidery cottons, is situated in the eastern section of the city and covers in all about fifty acres of land. The company is one of the largest industrial firms in that section of the country, employing between five and six thousand hands.

Each of the several mills comprising the plant was driven originally by a Corliss engine, nine engines in all, averaging 1,000 hp., the steam being supplied at 100 lb. pressure from four boiler plants located in the enclosure formed by the mills. Three of the boiler plants were served by one brick stack 335 ft. high and 14 ft. internal diameter at the top, erected in 1888. In 1907, a new plant, containing ten 4,270-sq.ft. Stirling type boilers to operate at 175 lb. pressure and 100 deg. superheat, was built to replace the three plants just referred to, which contained return-tubular boilers operating at 100 lb. pressure, the stack previously mentioned being used for the new plant.

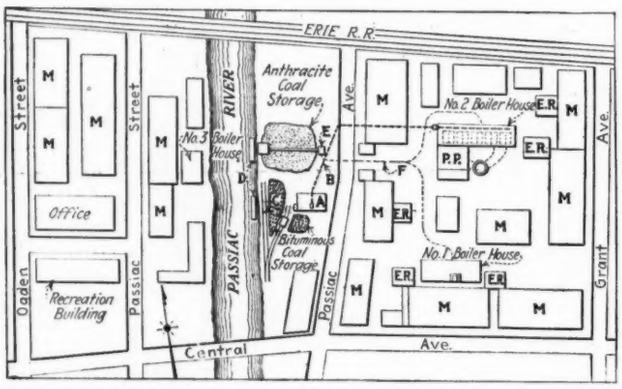


Fig. 1—Plot plan, showing location of preparation plant in relation to boiler house

A—Coal preparation plant; *B*—5-in. transport pipe placed underground through which coal is conveyed to boiler house; *C*—locomotive crane and coal storage track; *D*—Coal barges; *E*—Truck-loading hopper for anthracite; *F*—Route of anthracite coal truck that is being replaced by 5-in. transport line; *M*—Manufacturing plants; *ER*—Engine rooms, containing Corliss engines averaging 1,200 hp.; *PP*—Power plant containing three turbo-generator units having a total capacity of 11,000 kw.

The new plant constituted part of a program of rehabilitation and was erected preparatory to the electrification of the mills. Simultaneously with the construction of the boiler plant, a central power plant was built, the first unit, a 2,000-kw. turbo-generator, being placed in operation in 1909, at which time certain portions of the mills were converted to motor drive.

Since that time two units with a combined capacity of 9,000 kw. have been installed, and a number of the mills are now completely motor driven, including all those on the west side of the river. With the addition of one more unit sufficient capacity will be available for the complete electrification of all the mills. In addition to supplying all the steam for the generating station, the No. 2 boiler plant supplies approximately 60,000 lb. of steam per hour through reducing valves to three separate engines driving different mills. The No. 1 boiler plant supplies steam to two engines requiring about 40,000 lb. of steam per hour. This plant will shortly be replaced by further motorization of the mills or by a central steam header from No. 2 plant.

Early in 1922 it was realized that the capacity of the No. 2 boiler plant would soon be reached and that additional steam making capacity would be needed. Up to that time the boilers were hand-fired with No. 3 buckwheat, the coal being transported by trucks from the storage pile on the plot of ground situated between the Passaic River and Passaic Avenue, as shown in the plot plan, Fig. 1.

As slightly more than normal rating of the boilers had been obtained with hand-firing, it appeared that to install a method of firing whereby the boilers could be operated at any rating up to 250-300 per cent was the practical solution of the problem. In this way the steam-making capacity of the plant could be more than doubled with the present boiler installation.

In determining the manner of firing the boilers, a number of methods were considered, including the several types of stokers for small-sized anthracite and bituminous coal, pulverized coal and fuel oil.

As the location of the plant and the facilities for receiving the coal necessitated hauling all the coal across a busy main highway, it was decided to eliminate this process of handling if at all possible, and in view of this the problem was reduced to a choice of fuel oil or pulverized coal.

After a careful survey had been made of the relative advantages of these two fuels, it was decided to equip the boilers to burn either oil or pulverized coal since either could be transported to the plant by pipe line and the change could readily be made from one to the other without interruption in the boiler operation. As the price of oil at that time appeared prohibitive when compared with the cost of firing with pulverized coal, it was decided to delay the oil-burning installation until such time as the price should warrant the change. The furnaces, however, are designed for either method of firing.

Accordingly plans were laid for the construction of a coal preparation plant on the plot of ground normally used for coal storage and close to the point of unloading. The building is of structural steel frame with corrugated sheet-iron walls.

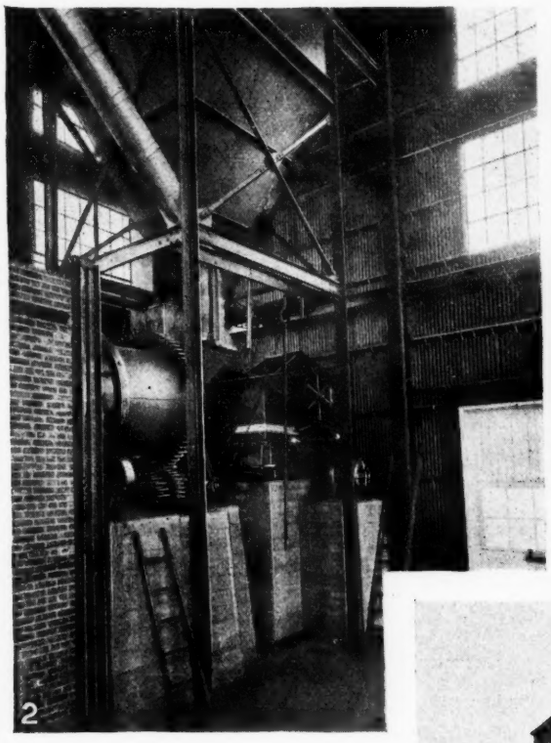


Fig. 2—Arrangement of coal crusher, elevator and rotary indirect-fired drier

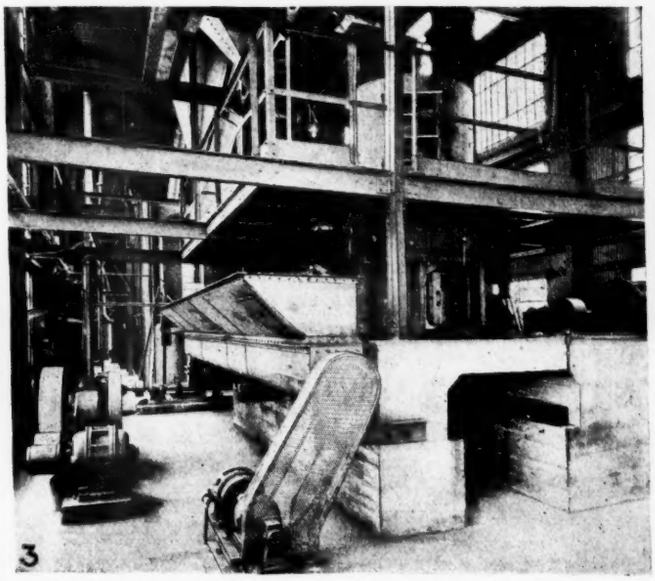


Fig. 3—Screen type mills discharge to screw conveyor which carries coal to transport pump

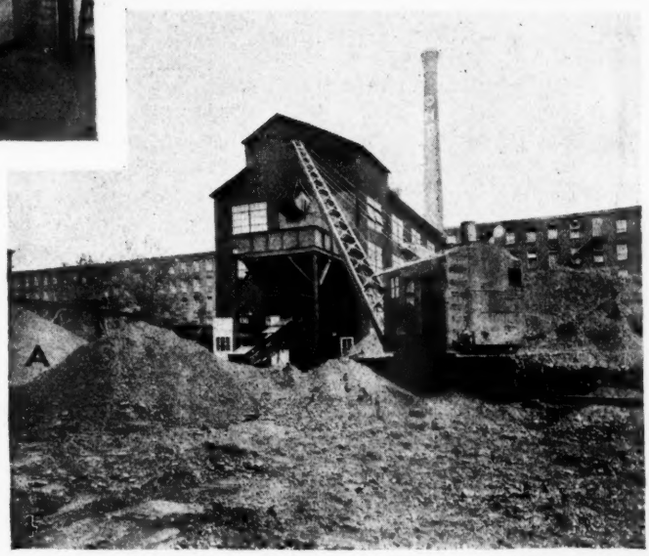


Fig. 4—Coal is unloaded from barge and delivered to preparation plant by locomotive crane

Fig. 5—Motor-driven transport pump which starts the pulverized coal in motion through the transport pipe

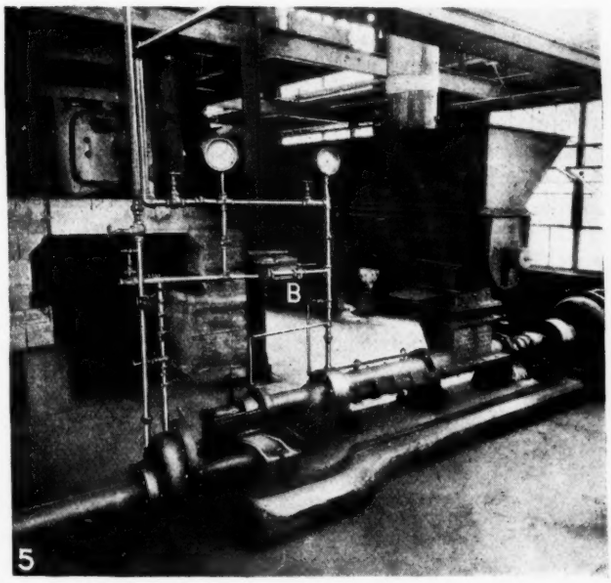
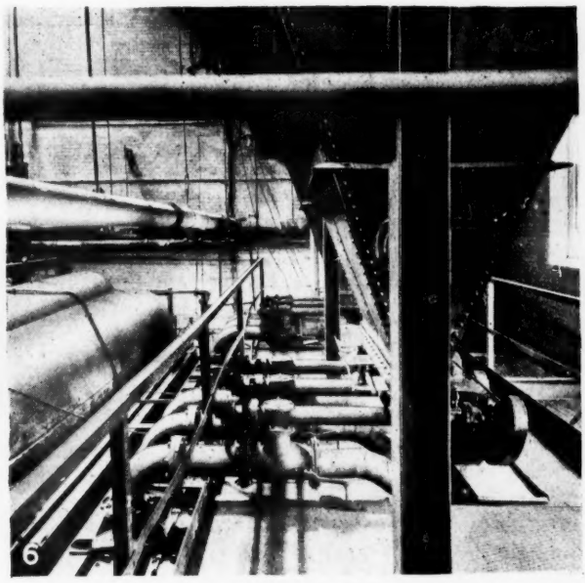


Fig. 6—Each furnace is fired by three vertical type burners placed in the top of the combustion chamber



Since it is essential in buildings of this kind that as few ledges as possible be made where dust can collect, the building was specially designed to eliminate this feature. Practically all horizontal structural members have been placed at an angle of 45 deg. from the normal position (see Fig. 2). In other words, the ends of the two legs of the angle-iron bars which constitute the major portion of the building structure are in the same plane facing outward. Provision has been made in the design of the building for liberal daylight illumination and ventilation by composing the side walls principally of windows. The location of the preparation plant in relation to the point of unloading the coal and the No. 2 boiler plant to which the pulverized fuel is supplied is shown in the plot plan, Fig. 1.

By referring to the longitudinal section, Fig. 9, the path of the coal through the process of crushing, drying, pulverizing and conveying can readily be traced.

The coal is delivered at the plant in barges and is unloaded to storage by a locomotive crane operating a 1-ton clamshell bucket. It is reclaimed from storage in the same way and delivered to a 20-ton hopper at the end of the pulverizing house. From the hopper it is carried by a pan conveyor to a single-roll crusher, immediately inside the building wall (see Fig. 2). Passing through the crusher, the coal is reduced to ¾-in. size and is then carried by a single-chain fixed-bucket elevator (No. 1) to the drier bin, from which it is fed by an adjustable feeder to the indirect-fired rotary drier. In passing through the drier, the moisture in the coal is reduced to less than 1 per cent.

The drier is fired with pulverized fuel through one horizontal-type burner. A screw feeder driven by a variable-speed motor is attached directly to the bottom of a small fuel bin adjacent to the drier, as shown in Fig. 9. As is usual with driers of this type, a large quantity of excess air is admitted to hold the temperature down to a safe point. This air is admitted through a door directly below the burner, and the temperature is controlled by regulating the speed of the feeder screw and the primary air that is supplied with the coal at the burner. This air is supplied at constant static pressure of 3 oz. by a motor-driven blower, and the quantity is controlled by regulating a damper in the air pipe at the mixing tee. The temperature of the drier is held around 500 to 550 deg. F., the coal leaving the drier having a temperature around 200 deg. F.

As the coal leaves the drier it passes to a bucket elevator (No. 2) and is carried overhead to a screw conveyor (No. 2) which conveys it to the dried-fuel bin above the pulverizing mills. In passing from the drier to the elevator it goes over a stationary magnet in the bottom of the chute, and this attracts and holds any tramp iron that may have entered the drier with the coal. The magnet is lowered from its position at intervals and the tramp iron removed.

The gases are removed from the drier by a motor-driven exhauster and discharged to a cyclone collector. Here the fine particles of coal are separated and returned to the dried-coal elevator (No. 2) while the gases pass to the atmosphere through a direct stack or a washer. The washer is used normally, as it is essential, owing to the nature of the product manufactured, to eliminate any dust in the vicinity of the mills.

Fig. 7—View of boiler room; boilers already converted to pulverized-coal firing in background

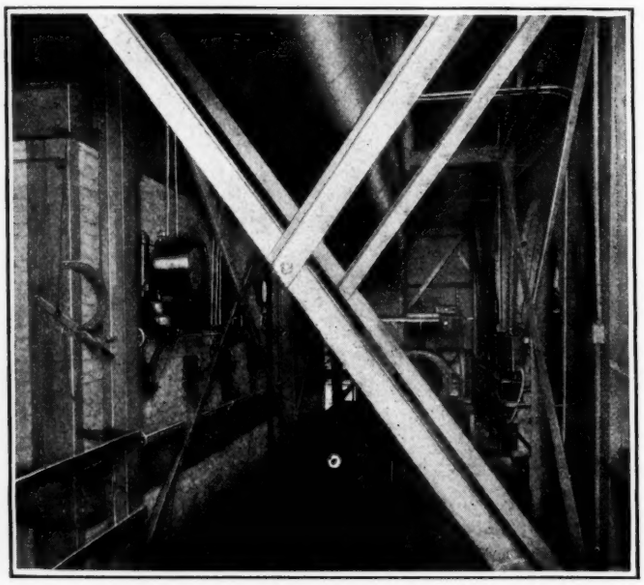


Fig. 8—Operating floor of pulverized-coal-fired boilers, all controls accessible from this floor

In addition to the screw conveyor previously mentioned for carrying the coal from the No. 2 elevator to the mill bins, a bypass screw conveyor (No. 1) is installed to handle any coal that may be sufficiently dry when received to be passed directly to the mill bins. This conveyor is 16 in. in diameter and is driven through a reduction gear by a 7½-hp. motor.

The present pulverizing installation consists of two 46-in. screen-separating-type mills directly connected to 100-hp. 550-volt motors. Each mill has a capacity of five tons of bituminous or three tons of anthracite coal per hour. The mills are directly below the dried-fuel bins and are placed on a concrete foundation about four feet above ground level. Provision is made in the layout of the pulverizing house for the future installation of one rotary drier and one pulverizing mill.

The mills discharge the pulverized coal into a 16-in. screw conveyor, No. 3 (see Figs. 3 and 9), which in turn

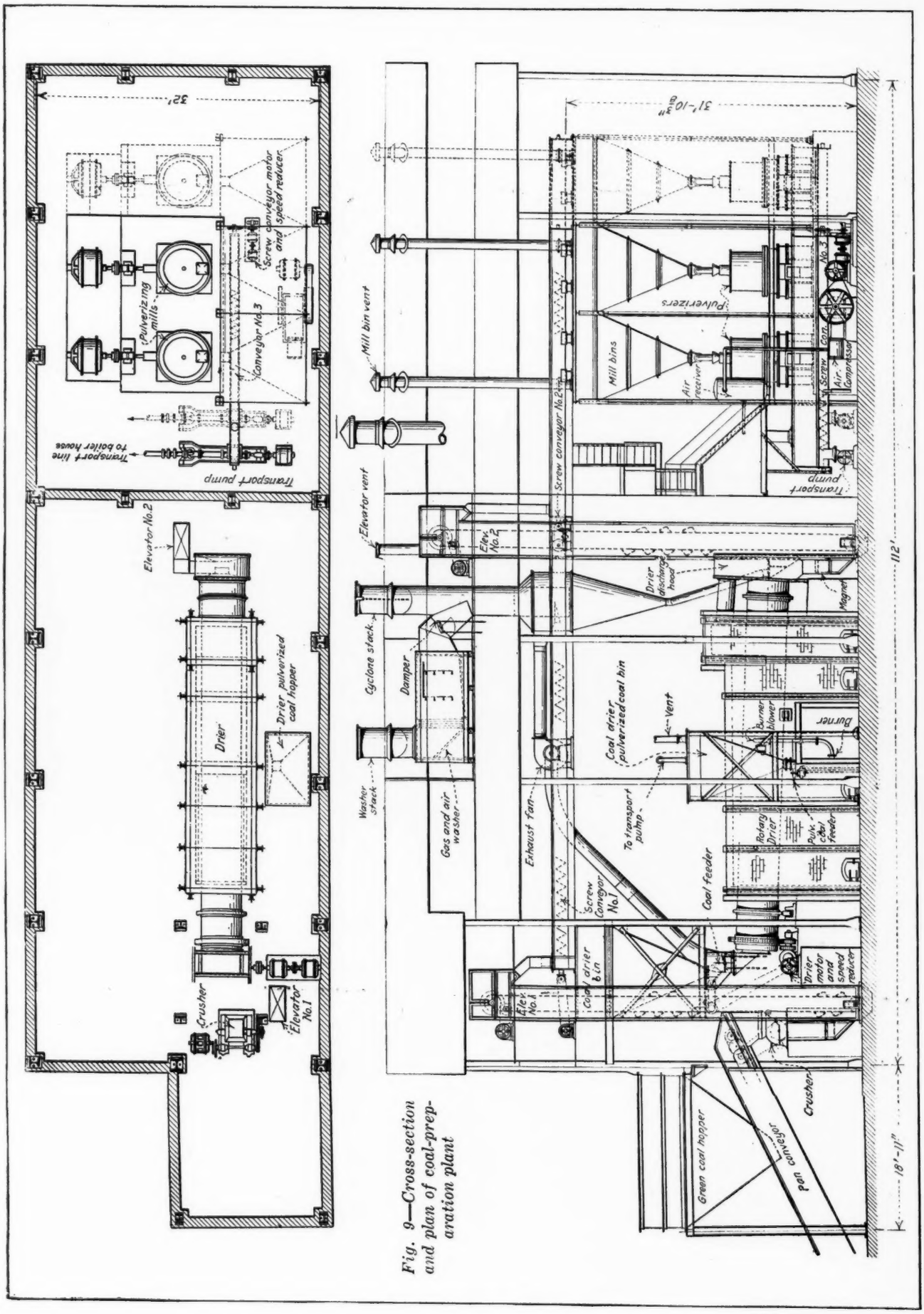


Fig. 9—Cross-section and plan of coal-preparation plant

delivers it to a motor-driven worm pump shown in Fig. 5. As the screw of the pump, which is revolved at high speed, carries the coal to the discharge end, it is aërated by a number of small-volume streams of compressed air at moderate pressure; this changes the nature of the material from a compact mass to a semi-fluid, in which state it is carried through a 5-in. transport pipe placed underground (passing under the street and buildings) a distance of 600 ft. to the No. 2 boiler plant. Just outside the boiler house the transport pipe rises vertically 30 ft. and is then carried horizontally over the fuel bins in the boiler room.

For supplying the necessary compressed air to aërate the coal in the transport line, a 215-cu.ft. per min. motor-driven air compressor and receiver are installed adjacent to the mills, as seen at the left of Fig. 3. A pressure of 60 lb. is maintained on the receiver, and the air admitted to the transport line is controlled by the regulator *B*, Fig. 5.

A switching or distributing valve is inserted in the transport line a short distance from the pump, and by means of this the coal is transferred to an auxiliary line feeding the pulverized-fuel bin at the drier. Additional distributing valves are inserted in the main transport pipe in the boiler room to supply the individual bins at each boiler.

The changes made in the boiler setting will be readily seen by referring to the cross-section, Fig. 10, the front wall of the old setting being indicated by a dot-and-dash line. The front wall of the boiler has been carried forward 5 ft. 1¼ in. and the floor of the combustion chamber lowered approximately 3 ft. This has increased the furnace volume from 850 to 2,550 cu.ft. approximately, the ratio of furnace volume to heating surface now being 0.59.

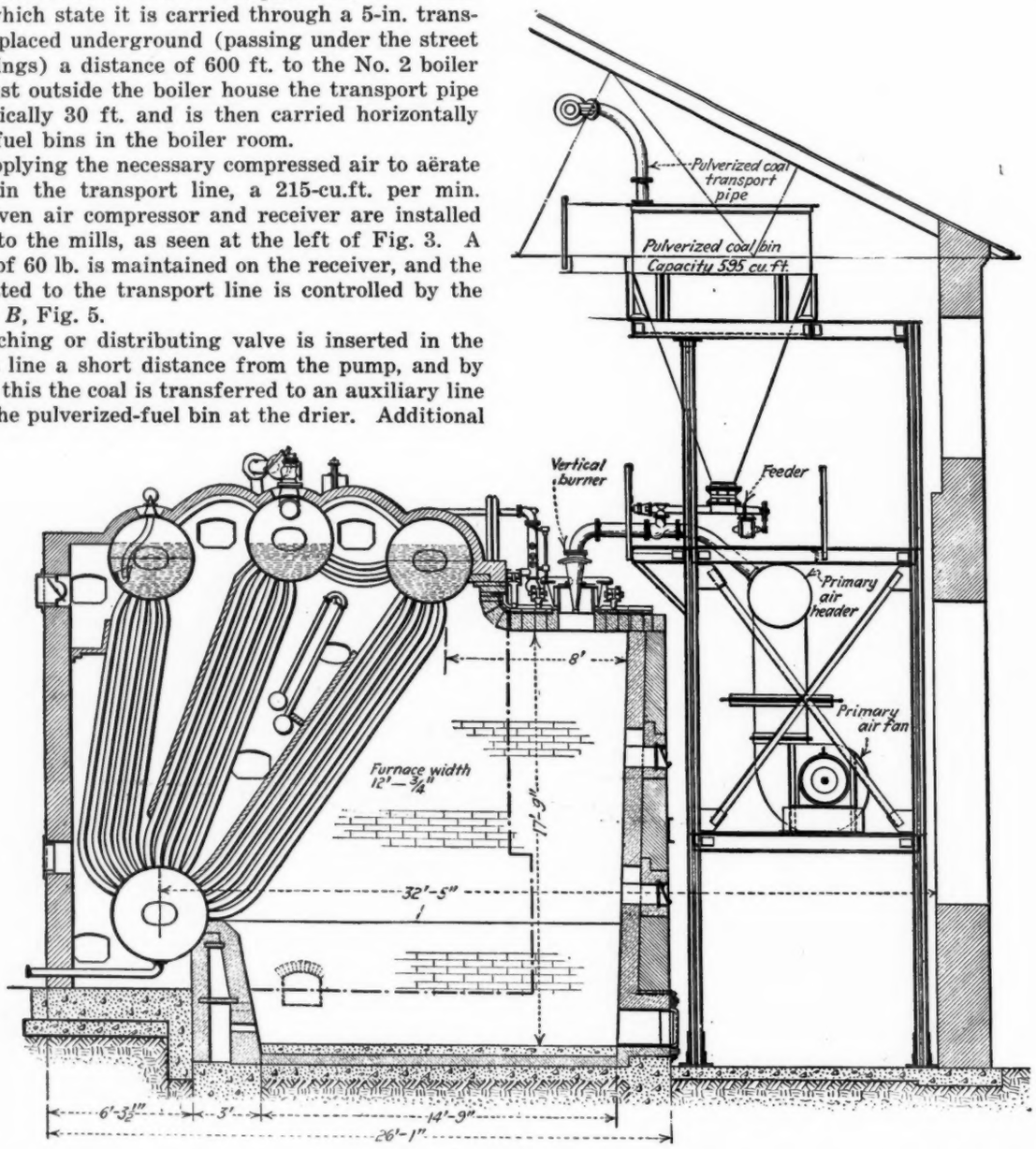


Fig. 10—Cross-section of furnace, also shows arrangement of primary-air fan, feeders and burners
Dot-and-dash line indicates outline of original furnaces.

Figs. 7 and 8 show the firing and operating floor of the boiler room before and after changing to pulverized coal. In Fig. 7 the extension to the combustion chamber and the steel structure supporting the operating floor and pulverized-fuel bins are seen in the background. At the time of writing three boilers have been converted to pulverized-coal firing, and if the present plans are carried out, the remaining boilers will be converted as rapidly as possible.

This change, however, did not necessitate any alteration to the boiler house, as the space normally occupied by the coal pile in front of the boilers was sufficient to provide ample operating floor space between the extended front wall of the boiler and the building wall. The steel structure supporting the operating floor and feeder floor was extended a sufficient height above the boiler to support the pulverized-coal bins. The bins are

constructed of steel plate and have a capacity of approximately 10 tons. The 5-in. pipe line through which the coal is transported from the pulverizing plant to the boiler house is carried horizontally along the roof trusses with a separate connection to the top of each bin, as shown in Fig. 10.

The top of the combustion chamber is formed by a flat arch in which an opening is provided for the burners. The inside width of the furnace is approximately 12 ft. and the burners, three in number, are placed in a row in the middle and spaced 2 ft. on centers. The general arrangement of the burners is more clearly shown in Fig. 6, in which it will be seen that the feeders are connected directly to the bottom of the pulverized-fuel bins, one of which is placed directly in front and above each boiler. The feeder screws discharge the coal into a tee in the feeder pipe, where it is mixed with the primary air, which constitutes approximately 30 per cent of the air required for combustion. Each feeder is independently driven by a variable-speed 1½-hp. direct-current motor through a silent chain.

All Motor Controls and Air Adjustments Accessible from Front of Boiler

The primary air is supplied by a 24,000-cu.ft. per min. motor-driven fan located on the operating floor at one end of the firing aisle. The fan discharges into a 36-in. header directly overhead. The header will eventually be extended the full length of the plant, and when the installation is complete an additional fan of the same capacity will be placed at the other end of the header. Either fan will have sufficient capacity for all boilers operating at 250 per cent of rating, thus leaving one unit as a spare. The secondary air is induced through adjustable air-inlet doors around the burners and through openings in the bridge wall and air-inlet doors in the front wall. All the motor starters and controls, as well as all primary- and secondary-air adjustments, are readily accessible from the front of the boilers (see Fig. 8).

An indicating and recording steam-flow meter is mounted on the front of each boiler in plain view of the operator, and this serves as a guide in regulating the speed of the feeders and the air admission for the desired ratings. Furnace operation has been adjusted to give 13 per cent CO_2 without slagging. No water screens are installed.

The ashes are removed from the furnace through a series of doors in the front wall. During the few months the boilers have been operated with an average rating of 175 per cent and peaks of over 250, it has been necessary to remove the ashes only once a week. The time required is about two hours per boiler, this being done at a time when the boiler is idle.

The complete coal drying, pulverizing, transporting and firing equipment was furnished by the Fuller-Lehigh Co.; pan conveyor, bucket elevators and screw conveyors by R. L. Latimer & Co.; coal crusher by Jeffrey Mfg. Co.; primary-air fan by the Buffalo Forge Co.; boiler arches by Detrick Co.; air compressor by Ingersoll-Rand Co.; alternating-current motors by General Electric Co.; direct-current motors by Star Electric Motor Co. All the engineering work on the complete installation was handled by the Fuller Engineering Co. The plant is operated under the direction of Alfred Lister, mechanical superintendent, and James Savage, chief engineer

Crankshaft Failures on Gas and Oil Engines

By Edw. Ingham

Failures of the crankshafts of gas and oil engines rarely occur on modern units, and this is to be attributed largely to that fact that engine builders put more metal into their designs than did their predecessors. In spite of increased dimensions and the use of better material, however, crankshaft failures cannot by any means be considered as things of the past, and for this reason a brief consideration of the principal causes of failure should prove of service to many.

Testing for Alignment

In some engines the shaft is supported on two bearings only; in others, it is supported on three, one at each end of the shaft near to the double-sweep crank and the third at the out end of the shaft beyond the flywheel. It is no easy matter to insure that each bearing will take its due share of the load, and if such is not the case, severe stresses are liable to be thrown upon the shaft, which may sooner or later set up a fracture. Even if the shaft is carefully lined up when the engine is first installed, there is always a possibility of the alignment's being altered, owing to sinking or yielding of part of the foundation or to uneven wear of the bearings. Hence, frequent testing for alignment should be made. At the examinations of gas and oil engines made by the inspectors of insurance companies, it is the practice to gage the distance between the crank webs at the part most remote from the crankpin, when the crank is in the uppermost and the lowermost positions. Any appreciable difference in the two measurements indicates that the shaft is subjected to severe bending stresses and requires lining up.

If all owners of gas and oil engines would make a practice of having their crankshafts tested in this way regularly and lined up immediately if found necessary, there is little doubt that crankshaft breakages would become much less frequent than they are at present.

Wöhler's Experiments on the Fatigue of Metals

Fatigue, the weakening that materials suffer through being repeatedly stressed, has always been an important factor in causing crankshaft fracture. Wöhler's experiments, carried out long ago on behalf of the Prussian Ministry of Commerce, showed that materials such as iron and steel could be fractured by repeated applications of a load much less than the static breaking load. The number of applications required to produce failure depends on the range of stress.

By keeping the range within a certain limit, the number of applications required may be rendered indefinitely great. In other words, if a part be designed of such dimensions that the range of stress—that is, the difference between the maximum tensile and the maximum compressive stress—is sufficiently small, failure from fatigue is out of the question. In actual practice, however, this would necessitate massive and costly designs, and the proportions are generally such that fatigue is a factor to be reckoned with. The important point to be observed is that undue stresses must be avoided. Provided the stresses are low, the parts may be worked for many years without becoming

appreciably weakened, but otherwise, they are liable to failure at an earlier date.

A most important consideration in crankshaft design is the avoidance of sharp corners or sudden changes of section, which constitute starting places for fractures. Many breakdowns have been traced to these sharp corners, and recent research has shown that even the fine grooves made by the cutting tool when turning the shaft in the lathe, may serve as places for the development of fractures. Hence it is highly essential that all corners in the shaft should be well rounded—that is, provided with large fillets.

Keys Should Be Well Fitted

Many fractures have originated at the corners of keyways both in crankshafts and in flywheel bosses, and it is somewhat strange that keyways are so often cut with sharp or square corners. If the keys are not well fitted, the tendency to start fractures at the corners is especially great, for both the flywheel and the shaft are exposed to repeated sudden applications of load, and the stresses resulting are unduly severe increasing the tendency to fatigue and failure. Frequently, a loose or badly fitting key will give rise to serious knocking, which should generally be taken as an indication of approaching breakdown.

Considering the severe conditions under which some gas engines work, it is not surprising that the keys occasionally tend to work loose. If the bore of the wheel is slightly larger than the diameter of the crankshaft, and if there is only a single key, the tendency of the key to work loose is especially great. In such cases, a plan recommended is to cut another keyway in the wheel boss, 90 deg. round from the other key, which is invariably a sunk key, and then fit a saddle key. The sunk key then serves to transmit the power, and the saddle key takes up any slackness. The importance of frequently testing the keys for any evidence of slackness cannot be too strongly urged.

Brittleness in Crankshafts

The material used in the manufacture of engine crankshafts is usually of high quality and thoroughly to be relied upon. Investigations of recent breakdowns appear to show, however, that occasionally the material is to some extent brittle, and any brittleness in a crankshaft is in the highest degree objectionable. This defect may be the result of improper heat treatment of the shaft during manufacture or to the presence of too much phosphorus in the steel. This substance tends to render the metal cold-short—that is, the metal cannot be worked cold without risk of fracture. Sulphur tends to render the metal red-short, and the steel cannot be worked at a red heat without risk of fracture. Hence these elements, sulphur and phosphorus, should not be present except in very small quantities.

The conditions of working in a gas engine are severe, far more so than in a steam engine. Whereas in the latter, the pressure is applied to the piston more or less gradually, in the former it is generated suddenly, and is applied in the nature of a shock or violent explosion each working cycle. The conditions, however, may be rendered still more severe should pre-ignition of the explosive charge be allowed to take place, the result of heavy deposits of carbon on the piston and the cylinder end. Cleaning the engine of these deposits is frequently neglected, being delayed until the last moment; in consequence, the working parts are unduly stressed, and the tendency of fractures in the crankshaft is increased.

Similarly, lubrication does not always receive the attention it should. If the piston lubrication be neglected, serious risk of a more or less complete seizure is entailed, and even if the seizure be only partial, excessive stresses will be thrown upon the connecting rod, crank and crankshaft. If the lubrication of the main bearings is not efficient, excessive friction and overheating will be the consequence, and the latter may give rise to surface fractures, which in turn may develop into more serious fractures.

Crankshaft Failure Is Rarely Sudden

It is a fortunate fact that crankshafts rarely fail suddenly. Failures are generally the result of a fracture that has gradually developed, and in many instances, fractured shafts have worked for years and have then been replaced before failure has occurred. Evidently, the discovery of a fracture does not by any means necessitate the immediate renewal of the shaft and consequent stoppage of the engine. Provided the fracture is carefully watched for signs of development, no serious risk is incurred in continuing to run the engine. Two methods are employed for finding out whether a fracture is extending. One is to put a center-punch mark at the end of the fracture and note in due course if the defect has extended beyond the mark. Another is to wrap a piece of tracing paper round the fractured part, and trace the fracture on the paper; the paper can then be applied to the shaft from time to time to see if any development has occurred.

The great difficulty in connection with a fracture is to decide when, owing to the development of the defect, the time has arrived for replacing the shaft. It is a big responsibility to run a fractured shaft, and the owner of the engine would generally do well to ask the advice of an expert.

There is a great advantage in having an engine insured with a reliable company. The regular examinations made by the trained inspectors of these companies are not only invaluable in discovering defects at an early stage, but the advice given concerning the general safe running of the engine relieves the power user of a great deal of anxiety.

Shaft Should Be Examined Frequently for Signs of Fracture

Whether the engine is insured or not, it is well for the engineer in charge to remove the caps of the main bearings from time to time, and make a careful examination of the shaft for any signs of fracture. A magnifying glass will be found useful in this connection. The main journals, the crankpin, and the webs in particular should receive attention. It is not always easy to distinguish surface marks from fractures. A real fracture may be suspected if there are any signs of what is termed "bleeding"; that is, exudation of oil reddened by rusting from the defective part. Should there be any doubt, it is always advisable to ask expert advice. Generally, fractures running in a circumferential direction, are to be regarded as more serious than longitudinal fractures, since they reduce the strength of the shaft to a much greater extent than do the longitudinal fractures. The latter, however, must not be regarded too lightly, as there are cases on record where these have gradually extended and ultimately led to failure of the shaft.

Maintenance of Oil Circuit Breaker Operating Mechanisms

By H. L. BIGGIN
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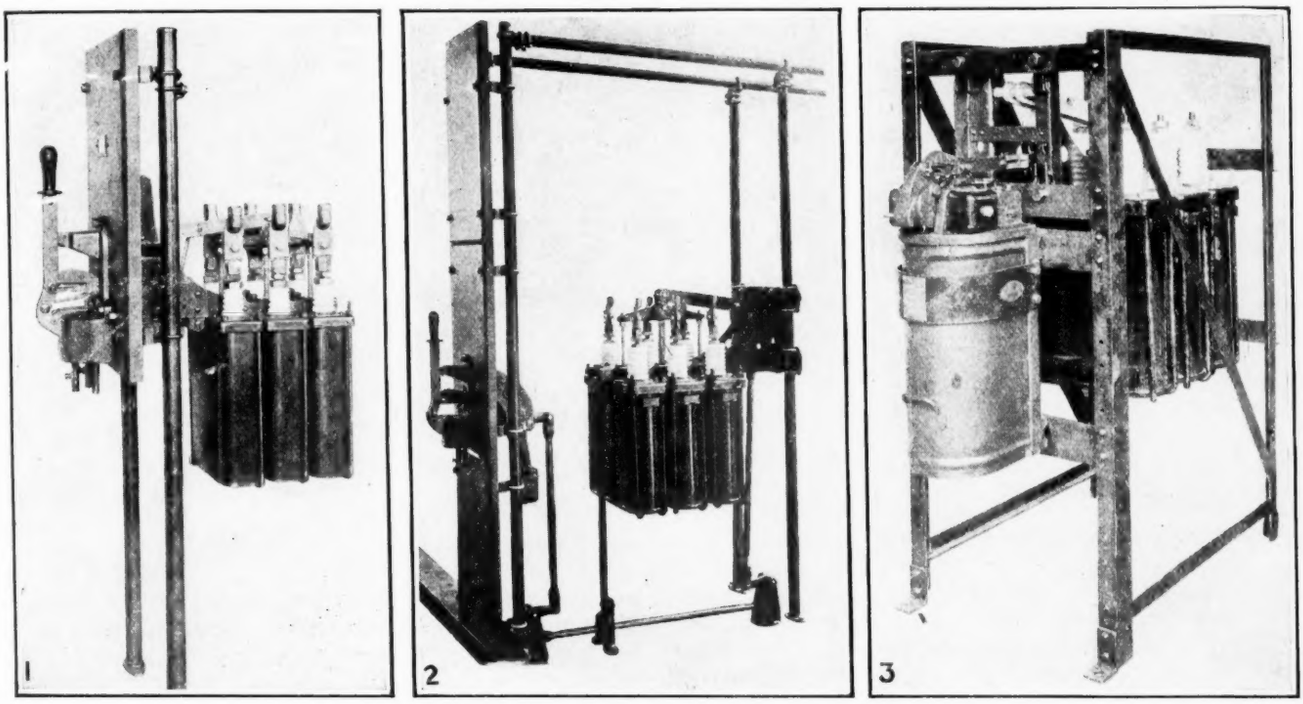
THE first of two articles on the operation and care of oil circuit breakers of ratings up to 15,000 volts. In this article the care of operating mechanisms is considered. A second article will treat of the care of switch contacts and oil.

PROPER protection to apparatus through reliable operation is the duty of the oil circuit breaker. Should a possible fault develop in the system to which it is connected, it must operate successfully to clear the trouble and in so doing save connected equipment from injury. To perform this duty, the oil circuit breaker must be given careful attention after it is installed and necessary adjustments made when they are needed. Parts requiring attention so as to insure proper breaker operation are practically the same in all makes and may be listed as: Mountings, operating mechanisms, contacts, connections, bushings, tanks and oil.



Figs. 1 to 3—Different methods of mounting oil circuit breakers

Mountings: Various ways of mounting the breaker, such as on slate or metal panels, pipe framework, angle-iron frames, and in brick or concrete cell structures, are used in present-day practice, some of which are shown in Figs. 1 to 3.

The oil circuit breaker with respect to its mountings, should be in such a position as to bring the oil level parallel with the tank rim, or in other words the tank rim (or edge) must be horizontal. If the breaker has been mounted in a position so as to bring the tank rim not horizontal, the right depth, or "head," of oil over the contacts will not be secured. Unless there is an adequate head of oil over the contacts, the hot gases generated at the arc when the breaker interrupts current, may not be sufficiently cooled by their upward passage through the oil, resulting in their igniting when they reach the air above, and causing an explosion.

The means of fastening the breaker proper to its support, such as by the use of bolts, should be examined at the regular inspection intervals and these fastenings tightened when necessary. The breaker must be fastened rigidly to its supporting structure, as otherwise the operation of the moving parts may be seriously impaired.

Operating Mechanisms: Proper operation of the oil circuit breaker depends primarily upon the correct adjustment and alignment of the operating mechanism. Operating mechanisms should be kept clean.

All bearing surfaces of the moving parts should be kept well oiled except where it is specifically stated by the maker not to oil a bearing surface, as is the case with certain bearings that require no external lubrication.

The operating mechanism is divided into two parts: (1) That part from which the initial movement occurs to close the breaker, such as the operating lever, Figs. 4 to 6, for a manually operated breaker; (2) the mechanism of the oil circuit breaker proper to which is

connected the operating rod with its movable contacts. In the case of a manually operated breaker for remote control, Fig. 2, there is really a third part, the connecting mechanism between the two parts mentioned, although this might be included as a part of (1).

Manual Operation: The initial movement to operate the oil circuit breaker may be given by hand through pushing on the operating lever shown in Fig. 4. In order to close the breaker, the lever must be in the position shown in the figure with the end of the toggle link engaging its catch. The lever is pushed forward to close the breaker to the position, Fig. 4. Unless the toggle link engages its catch, the backward thrust due to the weight of the moving parts of the breaker will prevent closing.

The operating lever is held in the closed position by means of a locking device consisting of a pin that fits into a groove in the lever catch.

To open the breaker by hand, it is necessary to lift up on the trip lever. The tripping screw mounted on the trip lever strikes the toggle tripping catch, and this in turn allows the toggle catch to be disengaged from the toggle link, and the force exerted by the weight of the breaker-operating mechanism opens the oil circuit breaker. The position of the operating lever is then as in Fig. 6, and in order to reclose the breaker it is necessary to return the operating lever to the open position, Fig. 4.

The switch may also be opened by pulling out on the operating lever, which causes the pin to be withdrawn from the groove in the lever catch. As this method takes more time to open the breaker than by tripping it as previously described, it is seldom used.

Automatic operation of the breaker in opening is obtained by the use of one or more trip coils mounted just below the operating-lever toggle mechanism. With the occurring of an overload on the system the plunger of the trip coil rises and strikes the tripping lever, and the opening of the breaker occurs in the same way as by tripping manually through lifting the trip lever.

These tripping coils may be energized from current transformers in the line or from a separate control source through the closed contacts of protective relays.

Provision for tripping the breaker when the voltage of the system drops below a prescribed value may be obtained by the use of an undervoltage release device mounted at the side of the operating lever and arranged through a small lever so as to lift the trip lever and open the breaker on undervoltage.

When the operating-lever mechanism is tripped and the breaker opened, the closing toggle for the bell-alarm contacts strikes against a lever, which in turn transmits the motion of the toggle to raise the spring contacts of the alarm device against the stationary pin contacts, closing the circuit to a bell alarm and thus giving indication through ringing of the bell, that the breaker has opened. The alarm circuit is opened by returning the operating lever to the position necessary for reclosing.

In order that the operating lever may close the breaker contacts properly, the length of the link connecting the operating lever with the circuit-breaker mechanism is adjustable by loosening a clamping bolt that holds the two sections of the link together. By lengthening or shortening this link as desired, proper adjustment to close the breaker contacts is obtained.

For correct operation in tripping the breaker, the tripping screw should be adjusted so that a slight clearance ($\frac{1}{16}$ in.) is between the head of the screw and the tripping catch.

The overload trip coils can be set for operating at a given current value by turning the thumbscrew on the calibrating tube. Raising this thumbscrew will decrease the current value through the coil necessary to cause its plunger to rise and strike the tripping catch, while lowering the thumbscrew will increase the operating current value of the trip coil.

The operating lever, Figs. 4 to 6, describes an arc of about 90 deg. of travel from its open to its closed position. In many cases the weight of the moving parts of the breaker requires the use of an operating lever having a greater leverage than 90 deg. This lever on some types of breakers has a travel of about 180 deg., or half a circle, from the open to the closed position.

Either of the two types of manual operating lever (90 deg. or 180 deg.) may be connected by means of a system of connecting rods and bell cranks to operate the breaker some distance away, as in Fig. 2. This

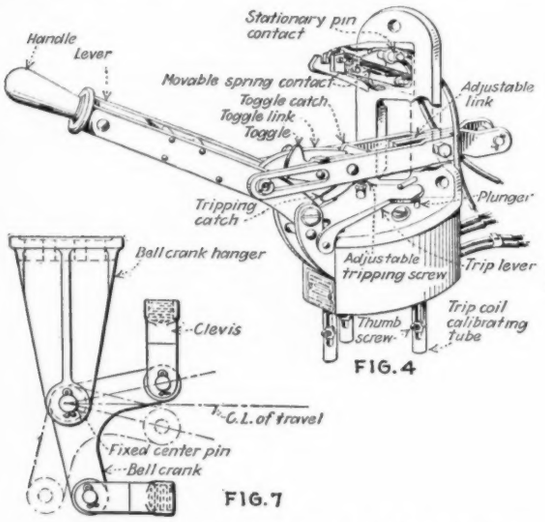


FIG. 4 FIG. 7

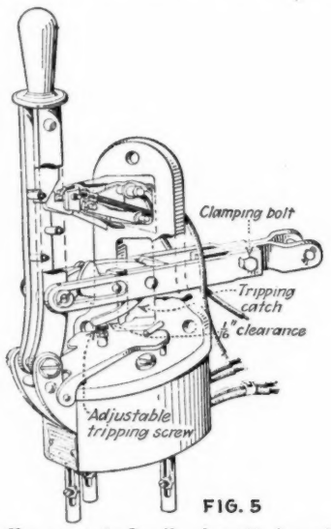


FIG. 5

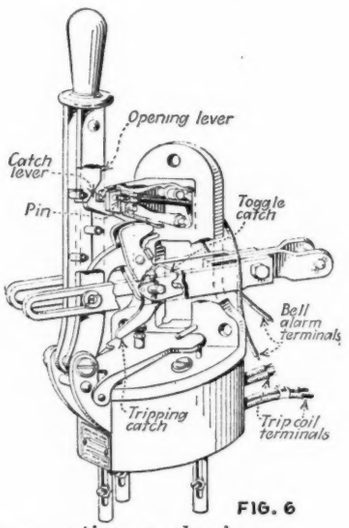


FIG. 6

Figs. 4 to 7—Different positions of a manually operated oil circuit breaker's operating mechanism

arrangement is used when it is desired to lessen the chance of the operator's coming in contact with the "live" parts of the circuit breaker.

Whenever possible, the connecting rods should be in tension in closing, as this does not buckle or bend the rods, as might be the case with the rods under compression when the breaker is being closed.

Adjustment of the rods should be such that the distances of travel in opening and closing the breaker from the center line of the bell crank are equal (see Fig. 7).

Electrical Operation: The closing motion may be initiated electrically by means of a solenoid operating mechanism, and the breaker operation controlled from

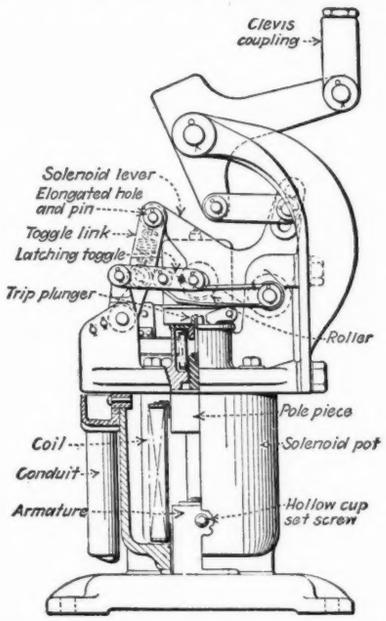


Fig. 8—Operating mechanism for electrically operated oil circuit breaker

a remote point by the use of a control switch operating through a control relay.

The solenoid mechanism consists essentially of a solenoid, Fig. 8, the plunger armature of which rises when the solenoid coil is energized and actuates a toggle-and-crank mechanism, which transmits the motion to the breaker-operating mechanism for closing the breaker.

As the upper end of the armature of the solenoid strikes the polepiece at the end of the closing stroke, the polepiece must receive the full force of the armature. If the solenoid mechanism is out of adjustment so that a stop on the breaker mechanism is encountered before the armature strikes its polepiece, the force exerted will severely strain and may possibly damage the mechanism.

The length of the solenoid plunger that is attached to the armature should be adjusted so that the latching toggle will lock the solenoid in the closed position just a little before the armature meets its polepiece. If the plunger is too short, the solenoid mechanism will not close the breaker before the latching toggle reaches its locked position. In order to have this adjustment, the large pin in the solenoid lever should be $\frac{1}{4}$ to $\frac{1}{2}$ in. from the lower side of the elongated hole in the toggle links when the armature is in the "up" position bearing against the polepiece and the latching toggle just latched.

To adjust the length of the solenoid plunger, it is necessary to remove the coil pot and closing coil. The solenoid armature has a tapped hole containing two setscrews, one of which bears against the plunger to keep it from turning and the other acts to lock the first in place. After removing both screws, the length of the plunger may be changed, by turning it, making only half-turn adjustments at a time.

The length of the connecting link between the lever of the solenoid and the crank on the breaker mechanism should be such that the latching toggle on the solenoid mechanism is just latched with the breaker closed.

When a solenoid mechanism is used with a breaker having brush-type contacts, it will be necessary to let the solenoid push the toggle on the breaker mechanism nearer to a dead-center position for closing than is necessary for breakers having finger contacts.

Electrical Operation on Alternating Current

For satisfactory operation electrically, using an alternating-current control source, a motor - operating mechanism is used to close the breaker. This mechanism may also be used with a direct-current source by using a direct-current motor to furnish the motive power for closing the breaker. The motor mechanism is controlled through a single-pole double-screw control switch and a control relay. The relay closes the motor circuit when the control switch is thrown to close the breaker and holds the control circuit closed until the breaker closes, even though the control switch is opened.

Test the tripping of the breaker by lifting the trip lever or by raising the trip coil plunger. The toggle links on the operating arm should work freely and the breaker trip open immediately. The adjusting screw on the tripping lever should not be too high, or the breaker will trip open immediately after closing. Moving parts of the mechanism should operate without binding; then operate the mechanism several times and observe its operation.

If the action of the motor mechanism does not close the breaker contacts fully, the length of the link connecting the motor mechanism with the breaker mechanism should be adjusted.

The breaker mechanism, which forms the connecting link between one of the devices already mentioned and the breaker-operating rod with its contacts, is made up of some form of crank-and-lever arrangement so that the initial closing (or opening) motion may be imparted to the operating rod and the movable contact mechanism.

In order that this mechanism will function at the desired time, it must be kept free from dirt and dried grease on the bearings. The bearing surfaces must be kept well lubricated with oil. Excessive play between bearing surfaces and moving parts should be remedied if possible, and in case of parts binding during operation of the mechanism, this binding should be remedied by a change in the adjustments of the parts affected.

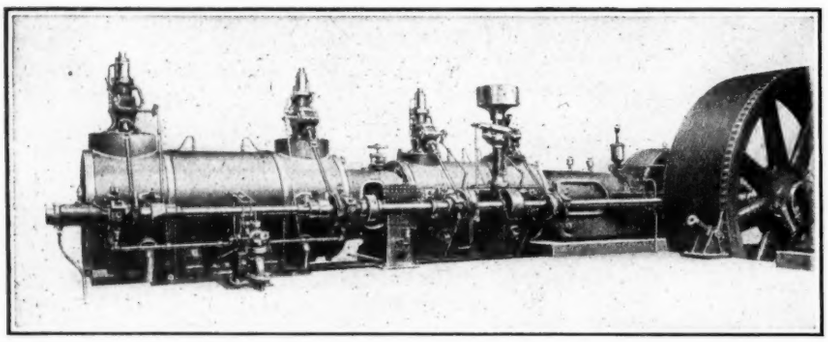
To make the breaker contacts open and close properly, it may be found necessary to adjust the operating rod (or rods) for the contacts. The rod is fastened to the operating mechanism by some form of clamping device, and the length of the rod may be changed by unclamping the rod and turning or moving it up or down until the contact movement is satisfactory. A second article will treat of the switch contacts and the oil.

Engines in Combined Power and Process Steam Plants

By John Cassiday

While it would at first glance seem that if all the exhaust of an engine was being used for process work, no better utilization of the heat in the steam is possible, this is incorrect, for in many instances it is possible to obtain from 25 per cent or more work out of the engine without any curtailment in the use of the exhaust. Even if we imagine the engine merely a reducing valve, it must not be forgotten that the more mechanical work we obtain before releasing the steam to the heating system or process, the cheaper does our power become.

It is by no means unusual to discover a plant where



Bleeding-type tandem steam engine

live steam is being used in process work for the reason that the load on the engine is so variable that the amount of heat in the engine exhaust does not synchronize with the process demand. Such an arrangement is wasteful and can be avoided by the choice of a suitable engine.

In England this subject has been given much attention and has led to the construction of "Heat Extraction" engines. A unit of this type, shown in the illustration, has a four-valve high-pressure and a unaflow low-pressure cylinder, together with an inter-receiver out of which is abstracted the steam required for processes. In operation sufficient steam is admitted into the high-pressure cylinder to carry the load under the existing process demands for heat. When the process steam demand is a maximum but little steam passes into the low-pressure cylinder, most of the high-pressure exhaust going into the process system. Under these conditions almost all the engine load is carried by the high-pressure cylinder, a pressure regulator having brought the low-pressure cutoff to its earliest point. If the process demand decreases, the receiver pressure rises slightly, causing the regulator to make the low-pressure cutoff later, which in turn permits this cylinder to carry more of the engine load. The resulting slight increase in speed acting on the engine governor shortens the high-pressure cutoff, bringing the speed to normal.

If the factory demand is greater than the steam entering the engine, live steam flows through a reducing valve into the factory line, suitable check valves preventing it from entering the receiver. In case there is no process demand, the engine operates as a tandem condensing unit. Galloways, who build this type of engine, state that the steam consumption of such a unit under various loads and with different amounts of steam extracted would be as follows:

	Net Steam Condensed per I.Hp.-Hour			
Engine load, i.hp.	130	200	275	350
When no steam is extracted	12.7	11.7	11.4	11.9
When 1,500 lb. per hour is extracted	7.7	8.0	8.5	9.3
When 3,000 lb. per hour is extracted	....	5.4	6.3	7.3

Such a system of bleeding can be used with any type of compound engine. The compound has an advantage over the simple engine exhausting at a high back pressure into the process mains, for steam control in accordance with the load and process demand permits the greatest possible economy to be obtained and places the reciprocating engine on a parity with the bleeder turbine.

Bleeding may be carried out in a single-cylinder unaflow by the introduction of ports along the cylinder barrel at points such that with normal operation the piston uncovers these ports when the cylinder pressure is somewhat higher than the desired drawoff pressure. The pressure-drop loss is of course greater than with the compound.

In heating plants it is generally assumed that it is necessary to carry one or two pounds gage pressure in the engine exhaust line. While the fairly high steam temperature resulting from such a back pressure is of advantage in reducing the amount of radiation needed to warm a factory, lower exhaust pressures can be and are carried in many plants. By hooking up the radiators or heating coils with a jet-type receiver a vacuum can be maintained on the entire pipe system, giving from 15 to 20 in. of vacuum at the engine. The extra horsepower obtained from each pound of steam is increased to a marked extent, and the installation can be made to respond automatically to the heating demand. If the demand is high the pressure in the heating line may be increased, which in turn raises the engine back pressure. To permit the engine to continue to carry its load under the new condition of back pressure the governor lengthens the cutoff and enough steam is admitted to maintain engine speed.

The same low back-pressure conditions may be had where the heating system uses hot water heated by the engine exhaust. By increasing the amount of radiation a lower water temperature will give satisfactory results and proper choice of water-heater capacity will cause the water heater to act as a condenser for the engine, giving from 15 to 18 in. vacuum.

Even in plants where the present design of the heating system precludes any success with below-atmosphere exhaust pressures, there is no reason why the engine should be operated during the summer with atmospheric exhaust. If one will visit any factory or office-building power plant during the warm months the exhaust steam will be seen blowing out the atmospheric line. Even in refrigerating plants or in plants where refrigeration is required in the factory, it is not unusual to see a cooling tower on the roof to recool the refrigerating condenser water, while at the same time the plea is made that there is no water available to condense the steam from the engine. Of course the amount of condensing water required by the engine is greater than for the refrigerating plant, still cooling

towers are not overly expensive. The placing of cooling towers on the roofs of office buildings, while calling for power for pumping, is not prohibitive in cost. The cooling-water system could be made a closed one and raw recooled water used in heat interchangers placed on the roof.

It can be stated with considerable logic that there is no plant operating non-condensing that could not show improvement by condensing operation. Engineers in charge of such plants owe a duty not only to the plant owner but to the public, to investigate ways and means of reducing the cost of power and betterment of exhaust conditions offers the greatest opportunity.

Equipment Cost in Muscatine, Iowa, Municipal Light Plant

In deciding upon the type of equipment to go into the municipal light plant at Muscatine, Iowa, the consulting engineer made a study of the possible load factor and operating conditions in the city to determine the most suitable type of prime mover. It was determined that within two years the plant would be operating at an annual load factor of 60 per cent, owing to the amount and kind of industrial power business available and the excellent water-pumping arrangement. Inasmuch as the plant would have an installed capacity of 3,500 kw. within two years and 6,000 kw. within seven years, the unaflow type steam engine was eliminated from consideration, as such an installation would involve too many units; furthermore, the unaflow engines offered no greater economy in operation than turbines owing to the favorable load factor of the plant and system.

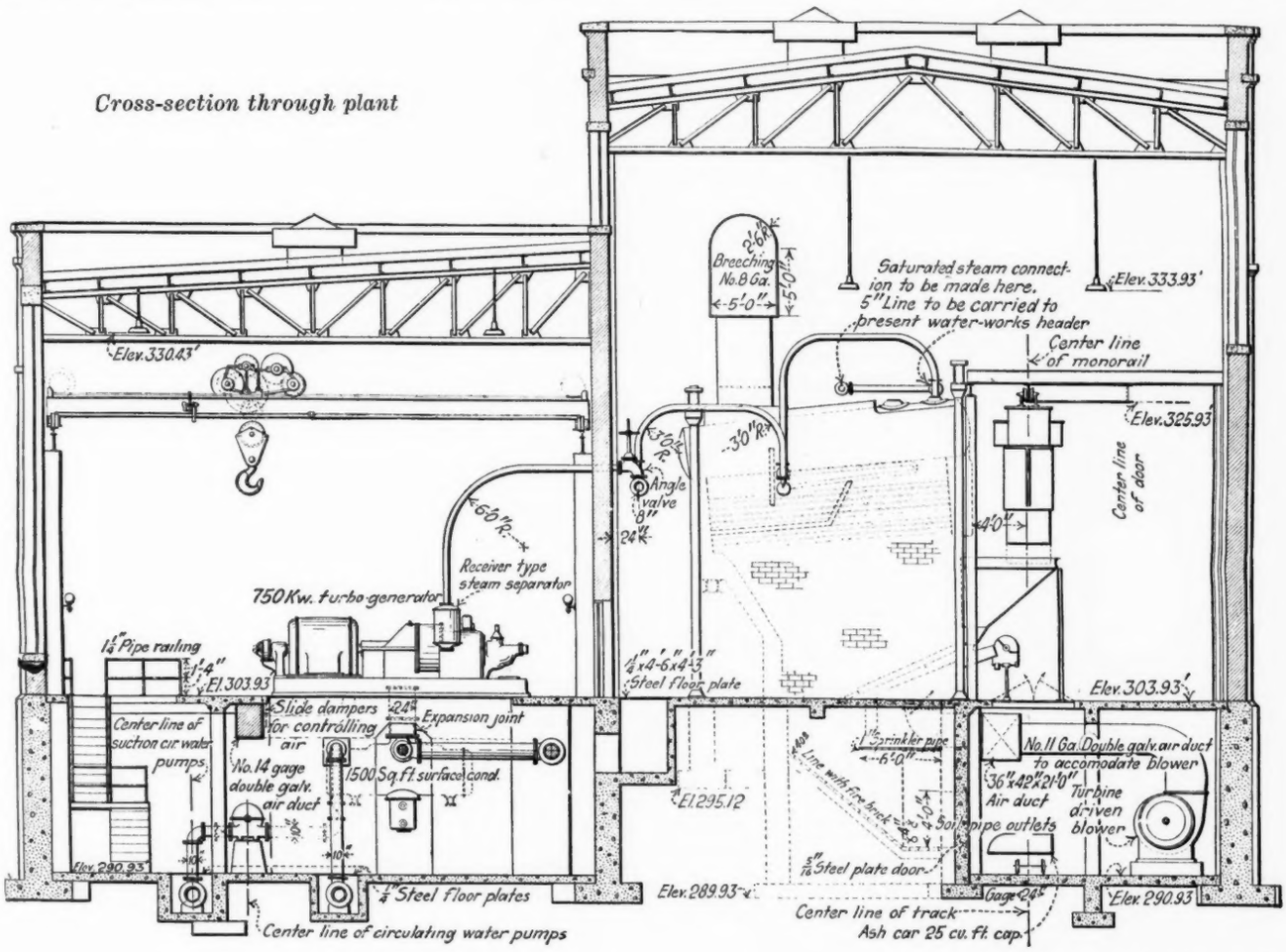
A thorough study was made of the Diesel engine and comparisons made with steam turbines, including all operating and fixed charges of the two machines. The following costs were arrived at for these two types of plants, the figures given being cents per kilowatt-hour of generated output at the switchboard:

	Plant Production Costs	Fixed Charges	Total Costs
At 60 Per Cent Load Factor:			
Diesel engines	0.75	1.00	1.75
Steam turbines	1.07	0.68	1.75
At 40 Per Cent Load Factor:			
Diesel engines	0.88	1.42	2.30
Steam turbines	1.34	0.94	2.28

The following is the basis of calculation of the foregoing figures: Coal, 11,000 B.t.u., $4.25 per ton delivered in storage; oil, 18,000 B.t.u., $0.05 per gal. delivered in storage; boiler efficiency, 75 per cent; turbine economy, 17 lb. steam per kw.-hr.; Diesel engine economy, 0.7 lb. oil per kw.-hr.; fixed charges on both types of plants, 13 per cent, determined as follows—interest 5 per cent, depreciation 5, maintenance 2, insurance, etc., 1 per cent.

The steam-turbine plant, substation and distributing system complete was estimated to cost $425,000 and the Diesel plant and system $525,000. Since there was no difference in the rate of charges of either plant, and the Diesel plant's initial cost was $100,000

Cross-section through plant



greater and a further gain would be made in the ultimate turbine installation, it was decided to use the steam turbines.

The plant has been designed for an ultimate capacity of 6,000 kw. and the present building constructed so as to house machinery of 3,500 kw. capacity. The initial installation of equipment consists of two 750-kw. 6,600-volt three-phase, 60-cycle turbo-generator units with surface condensers.

The boiler room contains two 3,500-sq.ft. 200-lb. water-tube boilers, with underfeed stokers.

The costs of the several items entering into the plant's construction are shown in the following table:

COST DATA, MUSCATINE, IOWA, MUNICIPAL PLANT

Power Station:	Total Cost Installed	Cost per Kw. Installed
Steam turbine-generators	$43,000.00	$28.75
Surface condensers	12,500.00	8.30
Boilers, superheaters, soot-blowers	32,000.00	21.25
Stokers, engines and forced draft equipment	12,500.00	8.35
Coal-handling equipment complete	18,000.00	12.00
Boiler-room accessories	10,000.00	6.65
Switchboard	12,000.00	8.00
Crane	3,000.00	2.00
Stack and breeching	8,000.00	5.35
Steam, exhaust, condenser and all plant piping and insulation	21,500.00	14.35
Building and foundations	58,000.00	38.75
Wells and equipment	2,000.00	1.35
Station cables and wiring	2,500.00	1.65
Total Station cost	$235,000.00	$156.25
Substation:		
Building	7,500.00	5.00
Switchboard	7,000.00	4.70
Outdoor transformers, delta-star steel outdoor substation and equipment	7,500.00	5.00
Station cables and outside distributing rack	3,000.00	2.00
Total Substation cost	$25,000.00	$16.70
Complete distribution, transmission and street-lighting systems, covering entire city	120,000.00	8.00
Cost per capita		7.05
Water pumping equipment and piping complete	15,000.00	
Engineering and incidentals	30,000.00	2.00

Power-station on building, piping and accessories complete and ready to receive additional one 2,000-kw. turbine and condensing equipment and one 5,000-sq.ft. boiler, which equipment installed would cost an added amount of $115,000, thus making total power station cost $350,000 for 3,500 kilowatt capacity, or $100.00 per kilowatt.

A summary of the principal equipment is as follows:

Boilers—Two 3,000-sq.ft. Heine Horizontal water-tube.
Stokers — Four-retort Westinghouse underfeed, driven by 12-hp. Wach steam engine.
Stack—150-ft. Weber reinforced-concrete 6 ft. diameter at top.
Forced draft fans—Two Buffalo Forge 19,000 c.f.m., each driven by 40-hp. Westinghouse motors.
Boiler-feed pumps — Two 125 gal. per min. outside-packed duplex Platt Iron Works pumps.
Heater — 45,000-lb. capacity Cochrane open type.
Coal handling—3-ton Shepard monorail and clamshell bucket.
Turbines—Two 750-kw. Westinghouse Elec. & Mfg. Co.
Condensers — Two 1,500-sq.ft. Westinghouse two-pass.
Circulating pump—Motor-driven, single-stage centrifugal.
Air pump—Motor-driven Westinghouse Le Blanc hydraulic.
Condensate pump—60 gal. per min. Westinghouse motor-driven centrifugal.
Crane—15-ton Whiting.
Oil filter—Richardson-Phoenix.
Floor grating—Irving.
Water-works pumps—Two 3,000,000-gal. per day De Laval two-stage centrifugal, driven by 200-kva. Electric Machinery Co., synchronous motor.

The total number of kilowatt-hours sold in Great Britain during the fiscal year ended March 31, 1924, increased by about 19 per cent over the previous 12-month period, according to the fourth annual report of the electricity commissioners, which has just been published. Of the 541 stations submitting returns for the year ended March 31, 1924, 248 were municipally owned, 190 privately owned, 75 belonged to railways and tramways, and 28 were nonstatutory undertakings. There has been a steady gain during recent years in the output of plants operated by "authorized undertakers," the term applied to systems either municipal or privately owned which operate under the formal authorization of the commission. The policy of the electricity commission has been to bring about wherever possible the replacement of a number of small central stations by a single large modern plant, in order to increase the efficiency of electric generation in England. —*Commerce Reports.*

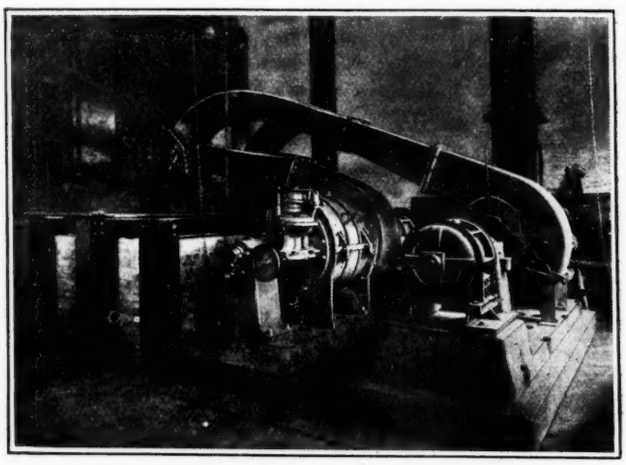
Unit System for Pulverized Coal

By S. C. Martin

The unit system for pulverized coal is practical for installation in plants where economy of fuel and labor is sought, together with low first cost of equipment, and where the space available for installing the apparatus is limited. The smaller power plant is thus enabled to profit by the advantages afforded by this class of fuel.

A minimum of attendance is required for operating a unit-type installation, and no especial skill is required of the fireman. Ash removal is in most cases a simple problem, less labor being needed than with hand-fired furnaces provided slag is not allowed to form.

Coal may usually be fed directly to the pulverizing machine without the necessity of first being dried, which is a desirable feature in the small plant. Power



Two unit-type pulverizers connected for parallel operation

is required for pulverizing the fuel only as it is burned, and no powdered coal remains in storage.

The illustration shows two unit-type pulverizers supplying powdered coal to a 5,000-sq.ft. cross-drum boiler, and the manner in which these machines are arranged makes a compact installation. Outside of the coal hopper and the magnetic separator for keeping tramp iron out of the machine, which are not shown, the pulverizer and burner constitute the entire equipment.

In the style of machine shown, coal enters through the rotary feeder, which may be seen on the pulverizer at the left, and the amount of material fed may be closely regulated either by hand or automatically. The powdered fuel is drawn out of the machine and carried to the burner by means of air which is supplied by a fan mounted on the pulverizer shaft, and while passing through the fan housing the fuel is mixed with sufficient air for combustion.

Two pulverizers installed in this manner make an economical equipment for a plant where the boiler is run at high rating for only a short time during a certain period, in which case one of the machines takes care of the normal load and the other is run only when the demand on the boiler makes it necessary to supply more fuel than the first machine can handle.

Lignite has been successfully pulverized and burned in plants equipped with the type of installation shown in the illustration, and tests on boilers supplied with

powdered lignite fuel that contained 25 per cent of moisture when entering the pulverizer, have shown a boiler and furnace efficiency of 76.8 per cent with an average of 15 per cent of CO_2.

The following test was made in 1923 on a unit-type pulverized-coal installation:

PULVERIZED-COAL TEST

Size and type of boiler	7,780 sq.ft. B & W
Pulverizers, number and capacity	two 4,000 lb. per hour
Kind and size of coal	Cambria Co. run-of-mine
Average Pressures, Temperatures, etc.	
Steam pressure, lb. gage	119
Temperature of feed water entering boiler, deg. F.	51
Temperature of escaping gases leaving boiler, deg. F.	475
Draft in breeching, inches	0.27
Draft in furnace, inches	0.05
Percentage of moisture in steam	0.86
Total Quantities	
Weight of coal as fired, lb.	27,543
Percentage of moisture in coal	1.76
Total weight of dry coal consumed, lb.	27,059
Total weight of water fed to the boiler, lb.	250,676
Total water evaporated, corrected for moisture in steam, lb.	248,520
Equivalent evaporation from and at 212 deg., lb.	300,237
Hourly Quantities and Rates	
Dry coal consumed per hour, lb.	3,382
Water evaporated per hour, corrected for quality of steam, lb.	31,965
Equivalent evoporation per hour from and at 212 deg., lb.,	37,529
Equivalent evaporation per hour from and at 212 deg. per sq.ft. of water-heating surface, lb.	4.82
Capacity	
Rated capacity, evaporation from and at 212 deg. per hr., lb,	26,841
Percentage of rated capacity developed	140
Economy Results	
Water evaporated per lb. of coal as fired, lb.	9.10
Water evaporated per lb. of dry coal, lb.	9.20
Equivalent evaporation from and at 212 deg. per lb. of dry coal, lb.	11.1
Efficiency	
Calorific value of 1 lb. of dry coal, B.t.u.	13,216
Efficiency of boiler furnace and grate, per cent.	81.5
Factor of evaporation	1.2081

Care of Commutators on New Machines

BY A. A. FREDERICKS

When a new direct-current machine is put into service, a little attention given to the commutator during the first few months of operation may mean a great deal later on in satisfactory service. It is in the first few months of service that the commutator is seasoning. When it is built, it is heated and the bolts drawn up tight, but however carefully this may be done, there is always the possibility of looseness developing after the machine is put into service. While in service the commutator is subjected to a heating and cooling process, which generally occurs once or twice per day, and all the time that it is in operation it is under a mechanical strain due to centrifugal force.

Although the majority of well-built commutators will remain tight after they have gone into service, it is well to try tightening up on the holding bolts every two or three weeks for the first three months, the setting up on the bolts being done when the commutator is hot, that is, just after shutting the machine down. Where the V-ring is in one piece, the tightening up process should be done by taking up a little on each bolt all around the commutator and then going over them all again. Should the V-ring be made in sections, the middle bolt in each section should be taken up first, afterward the end bolts and then any intermediate bolts.

Any unevenness that may develop while the commutator is being seasoned, should be taken down with a commutator stone. If too bad to be handled in this way, the commutator should be trued up with a lathe tool or grinding wheel. In tightening up flush commutators, the mica may have a tendency to rise slightly above the surface of the copper, but can be removed by a stone. Applying a stone to a glazed commutator is likely to result in the stone's picking up the glaze and copper. This can be avoided by first sandpapering the commutator until the glaze has been removed.

If a commutator has a true surface and does not spark at the brushes, it should soon take on a burnished surface of a dark-brown color. If abrasive brushes are used, they may cause the commutator's surface to remain in a raw condition. This should be carefully looked into and the brushes changed if need be. Today, with undercut mica in the commutator, it is generally unnecessary to use brushes that have a tendency to be abrasive. After a commutator has become burnished and has a true surface, it will generally be found that the least grinding that is done the better. If the commutator becomes dirty, it can be cleaned with a piece of canvas moistened with oil held against its surface just before shutting down the machine. After the machine has been shut down and while warm, the brushes and commutator should be wiped clean and the slots cleaned out if the mica is undercut.

Analyzing Gas Engine Exhaust

The practical value of gas analysis to the combustion engineer as a guide in the proper designing and operation of automotive engines is pointed out in Serial 2631, recently issued by the Bureau of Mines. Gas analysis is relied upon to a great extent by the combustion engineer in the design and operation of power and heating plants, but industry has made little use of gas analysis in the design and construction of internal-combustion engines. Certain cylinders may "load up" with gas at the expense of the others and when this occurs, due to some of the cylinders having too rich a mixture while in others it is too lean, efficient combustion is impossible.

Gas analysis enables the engineer to determine the quality of the mixture fed to the different cylinders with a high degree of precision. Briefly, the method consists in making an analysis of the exhaust gas from each cylinder while the engine is in operation.

The present method generally employed to determine distribution is to enrich the mixture fed to the engine until one or more cylinders begin to misfire. This indicates those cylinders that are running "rich," Then the mixture is "leaned" until misfiring again begins, which indicates those that are lean. In a way this method is satisfactory, but unless the ignition is perfect, misleading results will be obtained.

Automobile exhaust gas is a complex mixture of gases consisting mainly of carbon dioxide, carbon monoxide, oxygen, methane, hydrogen, and nitrogen, and at times gasoline vapor and traces of unsaturated hydrocarbons. For the determination of distribution a complete analysis of the exhaust is not necessary. All that is required is the percentage of carbon dioxide in the exhaust and the total carbon dioxide in the gas after the sample is burned in a slow-combustion pipette. The apparatus for making this determination consists only of a 100-c.c. measuring burette, a caustic pipette and a slow-combustion pipette. It is easy to manipulate, and dependable results may be obtained by an unskilled technician.

50,000 Kw. Compound Parsons Turbine for the Crawford Avenue Station*

The unit recently completed in England and shipped to Chicago, contains three turbine elements and three generators. A thermal efficiency of 27.8 per cent from coal to steam is expected.

THE cross-compound reaction turbine of 50,000 kw. normal capacity being erected in the new Crawford Avenue Power Station, Chicago, was originally built at Newcastle-on-Tyne, England. There are three cylinders in series on the steam flow, each driving an alternator, the three alternators being electrically coupled in parallel.

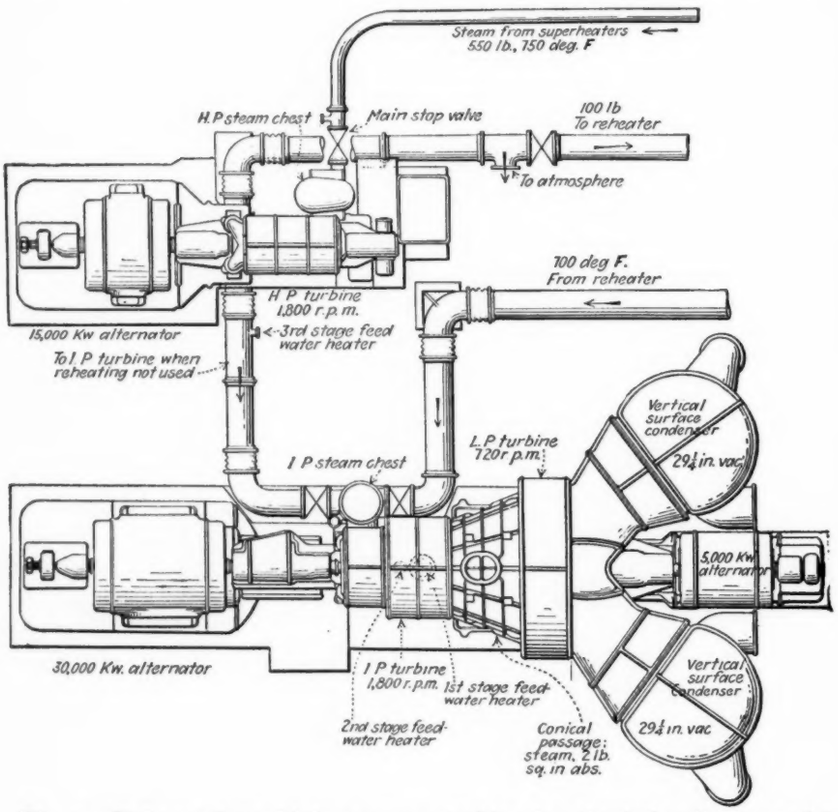


Fig. 1—Exhaust from high-pressure turbine is reheated and returned to intermediate cylinder

Steam is generated at 600 lb. pressure and supplied to the stop valve of the high-pressure turbine at 550 lb., superheated to 750 deg. F. After expansion in the high-pressure turbine to a pressure of 100 lb. above atmosphere, it is led back through a well-lagged pipe, Fig. 1, into a reheater in the boiler house from which it is returned to the intermediate-pressure turbine at a temperature of 700 deg. The high- and intermediate-pressure turbines run at 1,800 r.p.m. and drive alternators of 15,000 kw. and 30,000 kw. capacity respectively.

Further expansion takes place in the intermediate turbine to a pressure of about 2.0 lb. absolute, at which the steam enters the the low-pressure cylinder, to be expanded to the condenser vacuum.

The low-pressure turbine drives a 5,000-kw. alternator at 720 r.p.m. Owing to the lower revolutions of this turbine, the area provided in the final stage is so large that blades of normal profile, but set at a slightly greater discharge angle, can be employed.

The steam is condensed in twin surface condensers with the tubes vertical and having a total surface of 56,000 sq.ft. Fig. 2 is a sectional elevation of the intermediate- and low-pressure units. Fig. 3 is a photograph of a model. Table 1 gives the capacities and ratings of the various units.

In order to meet the demand for increased economy, steam pressure and temperature were raised above those in use in the United States at the time the general features were determined upon, while both stage bleeding and reheating then represented something of an innovation on such a large scale. Where high efficiency is the aim, sufficient exhaust-blade area should be provided so as to reduce the velocity of the steam leaving the last row of vanes to the lowest practicable amount.

An advantage of the cross-compound turbine is here realized, by operating the low-pressure unit at 720 r.p.m. Centrifugal force is not then a deterrent condition, and long blades may be provided with low stresses, thus giving ample exhaust area and reducing leaving losses to a minimum. By utilizing separate elements, pipe strains are confined to each end of each cylinder.

About 22 per cent of the total steam entering in the turbine is used for feed-water heating; it is extracted from the turbines at three points, the feed water being heated up from 65 deg. to 315 deg. F. in three stages before entering the economizers. A heat consumption of 10,265 B.t.u. per kw.-hr. is anticipated, or a thermal efficiency (from steam to electricity) of 33.2 per cent.

For recovery of the heat in the flue gases economizers are used for a final stage of feed-water heating, and air preheaters, a regenerative process being employed in the latter to heat up the incoming furnace air.

The boiler plant is expected to have an efficiency of 86.5 per cent. After allowing about 3 per cent for the total power absorbed by the auxiliaries, an over-all thermal efficiency (from coal to electricity) of 27.80 per cent is anticipated. This is on the basis of a boiler pressure of 600 lb. per sq.in. A schedule is given in Table II of the thermal efficiencies it is estimated could

*Abstract of paper by Sir Charles Parsons presented at the World Power Conference.

be realized with high boiler pressures, up to 2,000 lb.

Some details of the turbines and alternators will be of interest.

The three cylinders contain 64 simple turbines arranged in series, the first having blades 2½ in. long and ¾ in. wide on a mean diameter of 30½ in. and the last having blades 40 in. long and 3⅜ in. wide on a mean diameter of 160 in.

TABLE I—RATINGS OF THE INDIVIDUAL ELEMENTS OF THE PARSONS CROSS COMPOUND TURBINE AT NORMAL LOAD

Relative Pressure Range	Capacity Kw.	Speed, R.p.m.	Steam Supplied, Lb. Sq.in., Abs.	Total Temp. Deg. F.	Steam Exhausted
High.....	15,000	1,800	565	750	115 Lb. Sq.In. Abs.
Intermediate..	30,000	1,800	115	700	2 Lb. Sq.In., Abs.
Low.....	5,000	720	\2	...	29 ½-in. Vac.

Note—Friction loss in reheater and piping is not considered.

In view of the low density of the steam, the passages from the intermediate-pressure turbine onward have been specially designed to have the minimum of resistance and to avoid any sudden enlargements which would produce eddies or shock. The intermediate turbine discharges its steam directly into the low-pressure turbine through a conical annular space surrounding the intermediate bearings, and the energy of the leaving velocity of the intermediate exhaust is thus conserved, being converted into pressure.

The maximum blade tip velocity is reached at the last ring of the intermediate turbine, where it is 760 ft. per sec.; in the last turbine, which runs at 720 r.p.m. the maximum tip speed is 626 ft. per sec.

On the constructional side the most important feature of a turbine is its blading. There is probably no other part upon which so much ingenuity has been expended, and there are wide differences in practice as regards both materials used and the methods of manufacture and of attachment. The best-known system is that in which the blades are made of rolled brass strip fixed into the rotor or casing by calking spacing pieces between the blade roots. This system has been widely adopted in the past for both land and marine turbines, and has proved very satisfactory where the stresses and temperatures are moderate. When properly carried out this method gives a strength of attachment practically equal to the breaking strength of brass blades.

Many manufacturers and users now favor blades integral with their roots, and with such a formation higher stresses can be employed with suitable material. Such integral blades have until recently been formed by milling from the solid bar.

The roots are machined to suitable shapes or are serrated and attachment is effected by driving up the combined pieces in accurately machined or serrated grooves or slots.

Recent improvements in the methods of manufacture have, however, been developed at Heaton Works by means of which it is now possible to roll the blade integral with its root or spacing piece, and at the same time to form a radius at the junction of the two. This method of manufacture has the advantage of retaining the valuable feature of putting the grain or fiber of the material into the right direction for strength. It also subjects it to a strenuous test and has been found to detect faulty material with considerable certainty.

For these reasons such methods of rolling give a

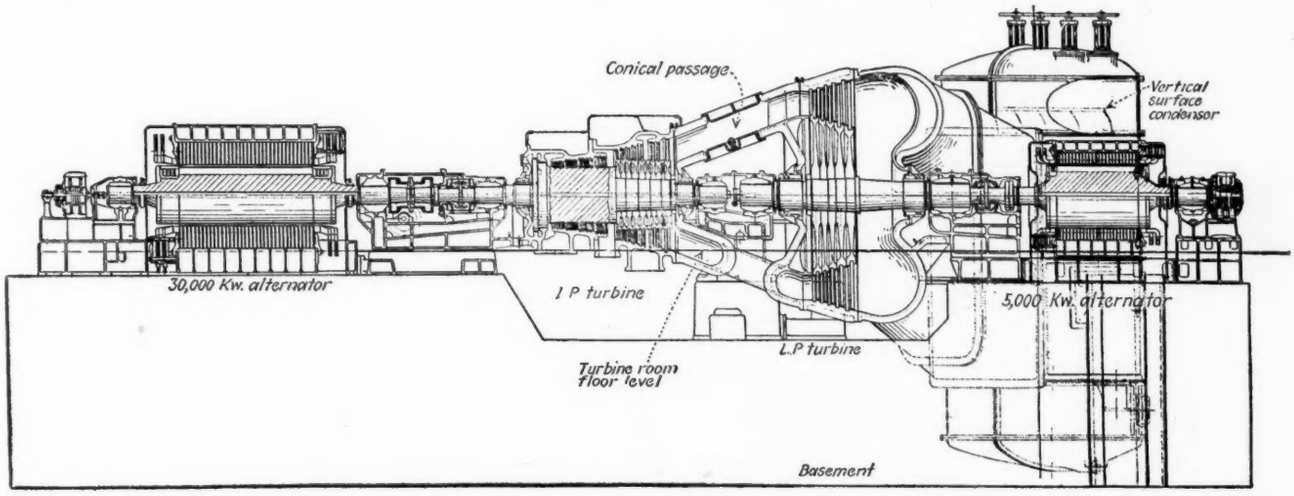


Fig. 2—Intermediate-pressure 1,800 r.p.m. turbine at left exhausts into 750 r.p.m. low-pressure element at right

TABLE II—SHOWING THE OVER-ALL THERMAL EFFICIENCIES WHICH IT IS ESTIMATED COULD BE REALIZED WITH INCREASED BOILER PRESSURES, UP TO 2,000 LB. SQ.IN.

(Based on the Callendar Tables and Formulae for the properties of steam)

Column No..	1	2	3	4	5	6	7	8	9	10	11	12
Case No.	Stop Valve Pressure Lb. Gage	Stop Valve Temperature Deg. F.	Deg. F. Initial Superheat	Assumed Reheat Pressure Lb. Abs.	Reheat Temp. Deg. F.	Restored Superheat Deg. F.	Exhaust Vacuum Ins. Hg. Bar. 30.0 In.	Stage Feed Water Heating From 65 Deg. F. Up to (Deg. F.)	Thermal Efficiency (From Steam to Electricity) Per Cent	Assumed Boiler Plant Efficiency (Including All Aux.) Per Cent	Over-all Thermal Efficiency (From Coal to Electricity) Per Cent	Gain Per Cent
I.....	250	750	344	65	700	402	29.25	360	31.6	84.0	26.52	.....
II.....	500	750	281	100	700	372	29.25	420	33.5	83.5	27.97	5.45
III.....	1,000	750	204	150	700	343	29.25	510	35.2	83.0	29.20	10.08
IV.....	1,500	750	153	250	700	299	29.25	550	36.6	82.5	30.20	13.82
V.....	2,000	750	114	400	700	254.5	29.25	600	37.5	82.0	30.75	15.90

3. Feed water heated to within about 50 deg. F. of boiler temperature by means of steam withdrawn from turbine blading at several points.
4. Boilers equipped with economizers or air pre-heaters or both, so as to recover heat from the flue gases and maintain high thermal efficiency.
5. Dynamo efficiency taken as 96.5 per cent. at full rated output.

superior product to that attainable by milling from the solid or by processes of drop forging or stamping, and are at the same time less costly.

In the 50,000-kw. turbine mentioned, the blades throughout are of mild steel, formed integral with their roots by this method of rolling. They are fitted in serrated grooves in both rotor and cylinder, being inserted and driven up tight. The blades of the high-pressure turbine and of the first half of the intermediate turbine are fitted with "end-tightened" shrouding made of manganese copper and brazed over tenons on the ends of the blades. "End-tightened" blading was introduced commercially in the year 1912, and has been widely adopted in land turbines of the reaction type and in several mercantile marine installations. In this type of blading the necessary running clearances are maintained in an axial direction, instead of radially, so that they can be made small and adjusted and regulated under the control of the thrust bearing. By using multi-cylinder turbines closer axial clearances can be used in lower-pressure blades than in a single-cylinder machine, as in the latter, expansion from the thrust bearing would be excessive. The minimum radial clearance of the portion of the blading that is end-tightened is $\frac{1}{4}$ in., while the radial clearances in the remainder of the blading range from $\frac{3}{8}$ in. up to $\frac{1}{2}$ in.

Each turbine shaft is fitted with an emergency governor, and these are interconnected so that any one of them will trip all steam admission valves simultaneously, and at the same time open a large vacuum breaking valve. In order to meet the special conditions that arise when reheating is adopted, the governing of the turbine has been arranged so as to avoid any danger of overspeeding due to stored steam. This is done by the provision of an independent governor valve on the inlet to the intermediate turbine, which receives steam from the reheater. The governor controlling this valve is set to operate at a speed about 2 per cent in excess of that of the main governor, and with this lag will control the rate of steam admission to the intermediate turbine whenever the load on the plant is suddenly reduced.

In case this valve should close for any reason, while the main high-pressure inlet remained open, a relief valve of ample area is provided on the exhaust pipe of the high-pressure turbine and set to open at 130 lb. per sq.in. above atmosphere, while an increase in pressure to 140 lb. will operate an additional tripping device and shut off the main steam supply.

The alternators are wound for three-phase 13,000 volts, and embody the latest British practice. No main field regulators are used in their operation, the regulation being carried out by means of well-designed exciter field rheostats.

The ventilation is effected by means of the closed circuit system employing surface air coolers and separately driven fans, which have a much higher efficiency than high-speed fans integral with the rotor shaft. The stator frames are being built in one piece, and the alternators have been shipped completely wound so as to be easily made ready for service.

Since when starting up the plant, there will be insufficient steam to drive the low-pressure turbine, the alternator coupled to this turbine will be run up as a synchronous induction motor. The three alternators will then by synchronized together and operated as one unit, giving a combined normal output of 50,000 kw.

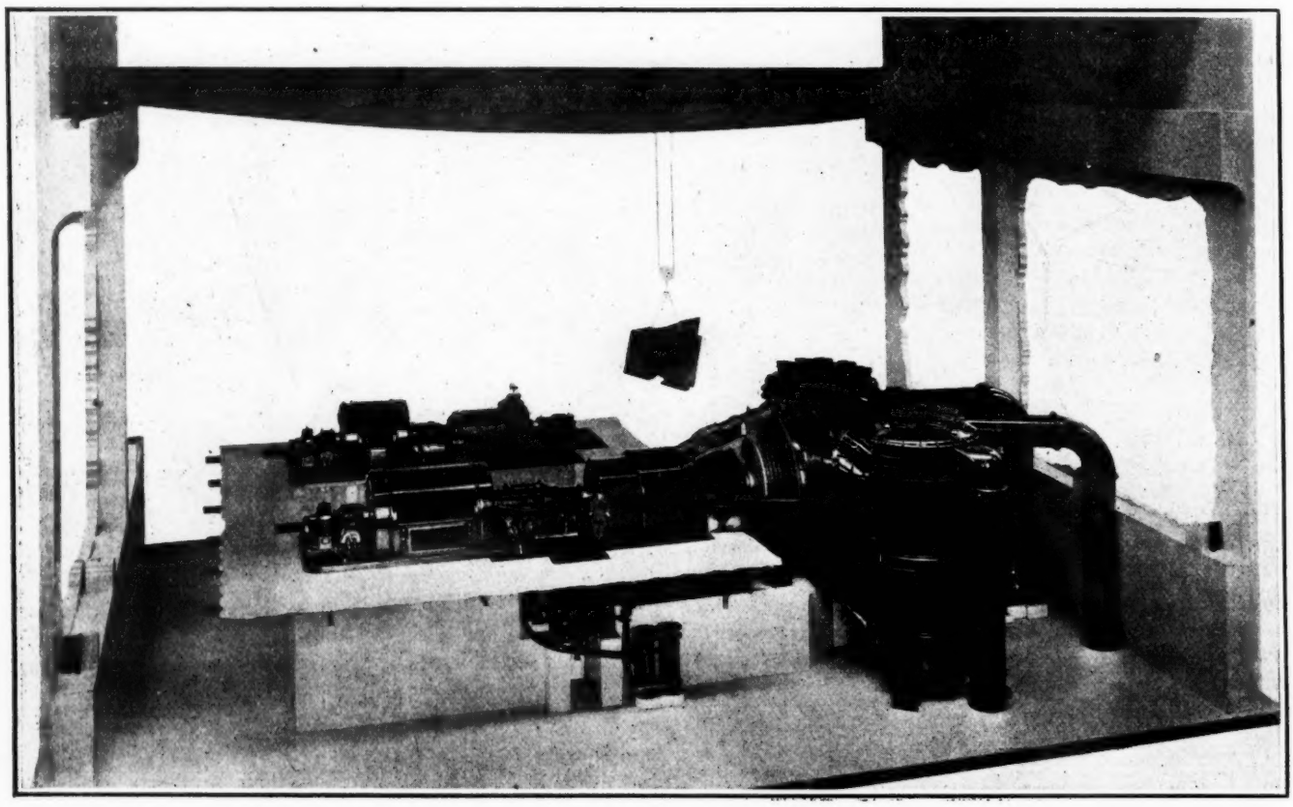


Fig. 3—Model of complete unit with vertical condensers exposing conical steam passage to low-pressure blades

Inertia

SIR ISAAC NEWTON stated a broader truth than he intended in his first law of motion, which runs to this effect: "Every body continues to remain in a state of rest or to move at constant speed in a straight line until compelled by some outside force to change that state of rest or of uniform motion." Just eliminate the space between the two words "every" and "body," and you have a fairly accurate picture of the average man's life, including that of the average engineer.

Take the case of the typical young operating engineer, or better, that of the fireman with ambition to become an operating engineer. He studies hard and works evenings to get a license or to raise the grade of his license. He appears to be extremely anxious for knowledge, exhibiting all the symptons of ambition.

Finally, he wins his first-class license, and at that moment reaches the real danger point of his career. The immediate incentive to study is gone. The license is a tangible thing, a passport to a better job. General self-improvement, though just as surely leading to advancement, is less tangible. The external force having been removed, the body continues from then on in a state of rest, or uniform motion in a straight line. Acceleration ceases.

A news item on page 747 of this issue tells something about the Michigan merit system of education, which has been inaugurated in the N.A.S.E. of that state, largely through the efforts of Garrett Burgess, the present National Vice-President. Here seems to be a real idea for a new and powerful incentive. How it works out will depend, of course, largely on how it is handled, but the latest reports are favorable.

Condenser Development

THE function of the condenser being comparatively simple, there was little in the types of a few years ago to suggest variations as utilized at present. From the developments as at present, it appears that power-plant design has been influential in ways hardly to be anticipated. Requirements of central-station service are ordinarily more exacting than for smaller plants, and departures from the usual practice are here most noticeable.

The more efficient utilization of condensing surface by investigating steam distribution, improving tube arrangement, steam laneing, etc., would appear as a logical step. It, however, has gone so far as to include special arrangements in the turbine exhaust to provide a uniform steam discharge against the tubes. A more radical movement is the separation of constant temperature condensation surface from that of falling temperature condensation or "devaporizing." One school applies the latter process in a vessel external to the main condenser shell.

Better tools for cleaning tubes and arrangements for doing this in one section of the condenser at a time while operating, are familiar expedients. There is a large future for improvement in this field, as heat transfer depends essentially on cleanliness and the average tube is capable of two or three times the heat transfer per square foot ordinarily realized.

The deaëration of feed water with consequent reduction of dissolved oxygen is a comparatively recent development of general power-plant practice. That the condenser hotwell could be utilized for this purpose would hardly have occurred to many observers. Furthermore, applying the boiler-feed pump directly at the condenser and providing a large hotwell to serve for storage of condensate, where oxygen could not be absorbed from the surrounding air, are steps closely identified with the application of stage bleeding for heating condensate.

As vacuums were increased from twenty-eight to twenty-nine inches, greater condenser-tube corrosion became noticeable. One theory advanced is that oxygen-producing organisms die at temperatures corresponding to the lower vacuums, but are active at the cooler temperatures. In arresting corrosion lies one of the future problems, on which much research has been and is being expended.

A combined condenser and boiler equipment is represented in the mercury turbine unit. There is little to serve as a basis that would suggest possible developments when plants are designed for radically higher temperatures and pressures.

Planning the Future Power System

EXPERIENCES during the last few years have shown that with few exceptions water power cannot be depended upon to supply the entire power needs of a community, no matter how great the water-power resources may be. This becomes more apparent as our water powers are developed nearer to the maximum and as the demands for service become more exacting.

When the old-time industrial centers depended upon water power almost entirely to drive their plants, if there came a period of low water it was accepted as something unavoidable and everybody patiently waited until it rained, when water was available to start business again. At the present time a power shortage is looked upon as a calamity, such is the dependence placed in power in all our activities, therefore a power supply, like a domestic water supply, must be practically unfailing.

Water powers may be divided into two classes, run-of-river developments, and those that have storage capacity, either natural or artificial. Large water storage can do much toward insuring a continuous power supply from a given stream, but experience has shown that over a period of years the largest storage capacity is likely to be entirely depleted. A power supply from a steam plant can be practically assured by providing

an adequate fuel supply against any emergency that may arise that would interfere with obtaining fuel. If coal is not available from one source, it may be obtained from another. Of if one class of fuel is not available, there is the possibility of changing to another. Therefore, there are a number of courses that may be taken advantage of in an emergency to insure a fuel supply to a steam plant. No such flexibility exists with the storage capacity of a water plant as with a steam plant. For an adequate water supply the changing characteristics of nature must be contended with. For periods of years the supply may always be in excess of demands, then over another period nature may not be so bountiful and an acute shortage may be the result. When such conditions arise, there is nothing that will meet the emergency but adequate steam capacity, as has been the experience in different parts of the country during the last five or six years.

The necessity of steam reserve in large water-power developments has changed the whole economic aspect, not only of making the developments, but also in operation. Where systems covering wide areas of country are interconnected, there may be run-of-river plants in one locality and plants that have storage capacity in another. The peak loads in one area may occur at a different time from those of another due either to a difference in time or to the characteristics of the load, or both. At the various seasons the rainfall may be different on one watershed from that on another, or the rainy seasons of the different sections may not coincide. Into such a diversity of water-power supply supplemental power must be provided by steam to insure against the effects of protracted droughts. If the steam plants are to give a maximum of service, they must be located at the most logical points.

To take into consideration all the factors and arrive at the most economical solution of the problem will require a careful study, not only of the individual systems, but of the interconnected system as a whole. These problems show that planning the power system of the future will not be in the design of a plant or individual systems, but the proper co-ordination of an interconnected system if the maximum of service is to be rendered with a minimum investment.

Another Suggested Steam Cycle

THAT stage bleeding for feed-water heating is economical has been proved both theoretically and by actual plant operation. Recently, the advantage of a cycle somewhat different in its thermal aspects from the regenerative has been outlined by James G. Weir in a paper read before the Institution of Engineers and Shipbuilders in Scotland.

In this paper it was pointed out that in establishing a criterion of efficiency for a steam-power unit, it is customary to study the performance of the boiler and its accessories separately from that of the turbine and its accessories in which the working cycle of the steam is carried out. The over-all efficiency of the power unit from the fuel viewpoint is then established as the product of the two factors. Certain useful practical considerations, however, emerge with greater clarity if the two processes are associated closely together.

It is suggested that there is room for improvement in the decreasing of the temperature difference between the furnace and the boiler contents, leading up to an increase in the water temperature. Since the flue-gas temperature at the boiler exit must be sufficiently above the boiler-water temperature to induce a heat transfer, it is evident that the difference between the furnace and boiler temperature is too great. If the temperature difference between the gases and the heat-receiving substance remains constant during the entire heat-absorption process, the temperature of the heat-receiving substance must be progressively at a lower temperature through the boiler. Obviously, this is impractical and unattainable, but a partial solution is found in the use of two boilers at different pressures and temperatures.

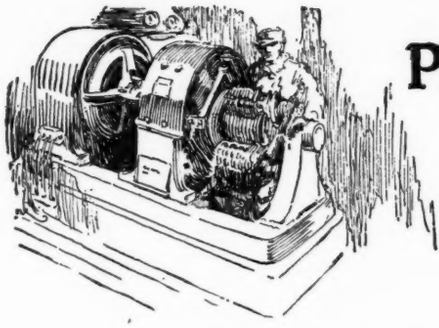
The process of combustion as planned is to be divided into two parts. In the first boiler the fuel is to be burned with less air than necessary to give complete combustion. While the furnace temperature will be less than normal, it is still considerably beyond that of the high-pressure steam in the primary boiler. The gases will then pass to a second furnace when the addition of air completes the combustion and raises the gas temperature. The gases will give up part of their heat to the low-pressure boiler and be further cooled by an air heater in the stack. The steam from the high-pressure boiler is to enter the first stage of the turbine, and part of it will be extracted in a later stage to heat the feed of both boilers; the low-pressure steam would enter the low side of the turbine and mix with the steam coming from the higher stages. Calculations given in the paper indicate that an improved efficiency would be obtained.

A Problem That Should Be Solved

WHETHER the plant be steam or water power, if it is located where temperatures below freezing are encountered, keeping an uninterrupted flow of fuel or water to the plant is a problem that must be faced in winter weather. In many water-power plants the problem of ice interfering with operation has not been satisfactorily solved. A variety of different schemes have been tried for combating the ice difficulties with varying degrees of success, but no remedy has been found that will meet all conditions.

As service requirements become more exacting, ice as a factor in interrupting service from a hydro-electric plant becomes more of a menace. Frequently, at the period when there is the greatest need for uninterrupted power service, the danger from ice is the greatest. Therefore, it is of the utmost importance that suitable methods be developed to keep water-power plant equipment free of ice.

Although considerable work has been done by a number of different engineers, up to the present time no comprehensive study has been made to the end of applying scientific methods to relieving the ice situation at water-power plants. A reading of the article in this issue on "Ice Problems at Hydro-Electric Plants" will show that there is a wide divergence of opinion on the matter and that practically every plant that has such problems to contend with has taken care of them in its own way. For these reasons the Committee on Ice Problems in Hydro-Electric Plants, appointed by the American Society of Civil Engineers, has an opportunity to do a far-reaching work and should have the hearty support of every one interested in water-power development.



Practical Ideas *from* Practical Men

How Much Does the Water Level Drop?

I should be glad to have, through the columns of *Power*, some information on the following:

If each of the following types of boilers are being operated at 200 per cent of normal rating and the damper is suddenly closed tight, how much will the water level drop, as indicated by the standard water column? For horizontal return-tubular, cross-drum, straight-drum, stirling or "V" type water-tube boilers, also Badenhausen type boilers. GUY B. RANDALL.

Dayton, Ohio.

Getting Rid of Noise in the Power Plant

One of the troubles of the power plant is "noise," but much of the "noise" we have to contend with is easily eliminated by the exercise of a little care and attention.

Discussing this question recently with a friend who has charge of a large refrigerator plant, he appeared very much distressed about the noise in his plant, so I decided to pay him a call and, if possible, give him some assistance. On my arrival he was most anxious to show me around at once, but I preferred to have a few minutes' chat just inside the door and soon was able to inform him that I counted more than a dozen different "noises," several of which could be considered as superfluous. On the engine nearest the doors were several distinct noises that I told him could be removed at once. This engine was of 250 hp. and operated on suction gas. The valve-lever rollers actuated by the cams gave a decided click, due entirely to the use of a thin instead of a heavy oil. A heavy grease, which happened to be on hand, was immediately applied and the noise practically disappeared. Owing to careless spring adjustment two valves banged down, each with a different noise, and little trouble was necessary to bring this into line as a single noise, which was not so irritating. The crankpin end of the connecting rod was lubricated by a cup lubricator catching the end of a pipe each revolution and wiping off a small amount of oil. This produced another sort of click, which, by raising the pipe slightly and inserting a small piece of wire and cotton wool, was entirely removed.

Passing along through the plant, we discovered a small belt-driven pump. On the belt was a metal fastener that gave a decided click on the guides each revolution. A slight adjustment of the guides entirely removed the click. Then we came to the pet noise, which, as he explained, he could not account for at all. This proceeded from a generator that was driven by an 8-in. six-ply belt from a 48-in. pulley on a countershaft. Upon investigation we found the inside ply of the belt was cracked through in several places, permitting air pockets to form between the plies of the belt. As these pockets passed over the pulleys they certainly made a most annoying racket. This was almost entirely eliminated by turning the belt inside out.

There were several more simple reasons for noise in this particular plant, but the foregoing are sufficient to show that much can be removed. My friend is considered a clever engineer, and undoubtedly is, but often it is the clever ones who overlook these simple causes of noise. To remove them altogether is, I fear, impossible, but as many of them as possible should be got rid of, as a quiet running plant does much to enhance the reputation of the engineer in charge.

Belfast, Ireland. F. P. TERRY.

Renewing Feed Pipe in Return-Tubular Boilers

Some months after taking charge of a boiler plant consisting of several 72-in. by 18-ft. horizontal return-tubular boilers, two of the boilers were blown down and opened up for the annual internal inspection.

Upon entering the boilers I found that the feed pipe in each one had broken off at the bushing in the front tube sheet, leaving the short threaded portion of the pipe in the coupling that connected the feed pipe and the bushing.

As there was very little space between the stays supporting the front head, it was impossible to get a pipe wrench of sufficient size on the coupling to remove it, so some other method had to be devised. We finally hit upon the plan of drilling a row of holes in the top of the coupling with a portable motor-driven drill and opening up the coupling with a chisel. This was done and the couplings were removed without difficulty.

Upon preparing a new section of pipe and pushing it in below the tubes through the lower manhole, we discovered that there was not sufficient room between the central rows of tubes to draw the pipe up into position. This difficulty was overcome by dropping two short pieces of rope down between the outer rows of tubes and the shell and drawing the pipe up.

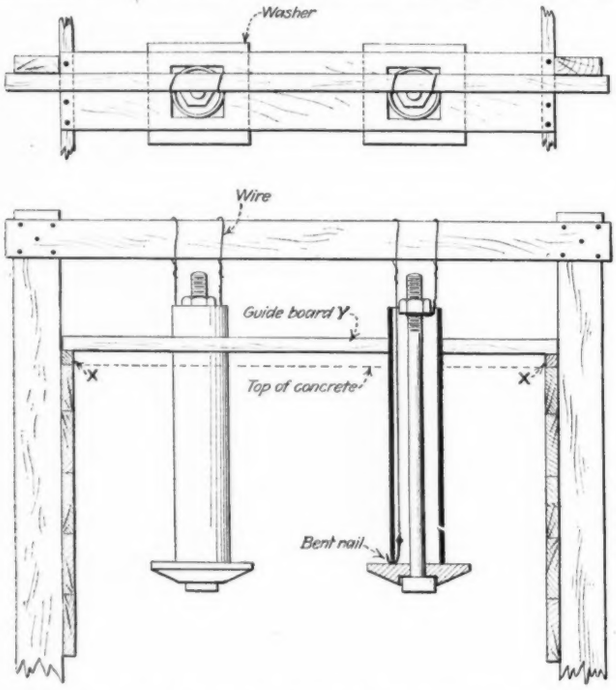
When the boiler was opened up again the following year, exactly the same condition was found, the pipes being broken off at the same point as before. We then decided to install brass pipe and have had no further trouble.

Previously to my connection with the plant considerable pitting had taken place on the lower part of the shell and some of the upper tubes. As the feed water was practically all condensate, very little fresh water being added, we concluded this to be the cause of the pitting. To prevent further pitting or to reduce it as much as possible, we made it a rule to empty the boilers at least once a month and refill them with fresh water. This has practically stopped the pitting.

Worcester, Mass. LEROY BLAKE.

Removing Pipe Around Anchor Bolts

In order that time may be saved in the setting of machinery, many foundations are built before the machines arrive. To do this the forms must be made from the blueprints without the use of templets to locate the anchor bolts exactly. Much machinery nowadays is so large and of such great weight that it is difficult to get a bolt templet from the actual machine.



Pipes are revolved at intervals while concrete is setting, then finally removed

It has been the custom to build the forms and place the anchor bolts inside pipes of a larger diameter and thus allow considerable movement of the bolt. After the machine is set, the pipes are filled with grout. This has its disadvantages. It is known that concrete or grout will not adhere to a greasy or rusty surface, such as many of these pipes have. As a result, especially if the machine is subject to much vibration, the pipe loosens in the concrete, or the grout inside the pipe loosens and breaks up or crumbles. As a final result the bolts become loose and permit more vibration.

To overcome this trouble, the following method of placing the bolts has been tried and found satisfactory. The pipe is so suspended that at least two or three inches, more if possible, will be above the top of the concrete. Arrangements may be made as in the illustration, care being taken to have the guide board *Y* ¾ in. or more above the concrete. This permits working the concrete underneath the board. Small blocks *X* of right thickness may be used for this purpose. After the concrete is poured and has begun to set, turn the pipes with a pipe wrench or an ordinary monkey wrench by slipping it over the end of the pipe. This should be done at intervals of not more than an hour while the concrete is setting. When the concrete is set sufficiently to support itself, withdraw the pipe entirely, which it will be found can be done without difficulty. This method has two advantages: First, it permits greater movement of the bolt, and second, when the grout is poured into the hole it will adhere firmly to the concrete, thus fastening the bolt to the foundation not only at the anchor plate, but its full length as well.

This method has proved satisfactory where leaving the pipe in the foundation has failed.

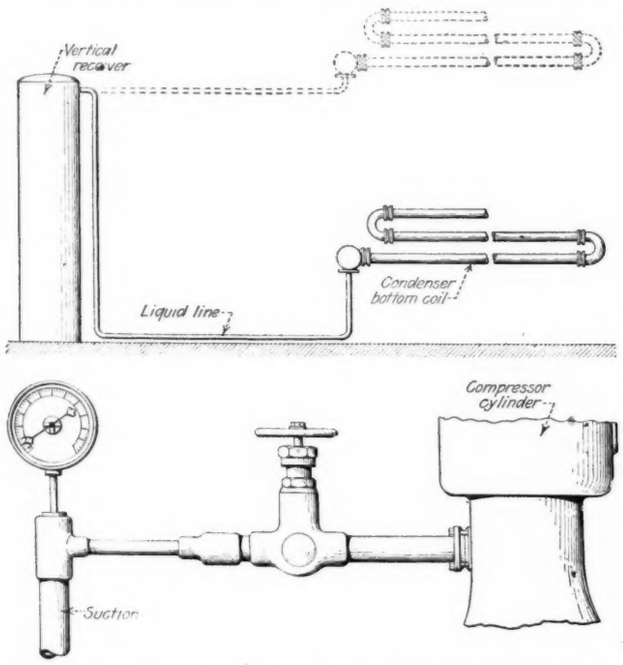
Troy, N. Y. S. D. BARCLAY.

Correcting Troubles in a Small Ammonia Plant

Some time ago I was called upon to locate the trouble in a small ammonia plant. A brief outline of the plant layout and the changes that were made in correcting the trouble follows.

The owner, who was also the engineer, complained that he could not get the ammonia to go through the system. Upon investigation we found the liquid line from the condenser to the receiver was dropped to the floor line and then carried along the floor to the receiver, then up the side where it entered near the top. This was corrected by raising the condenser and running the line direct to the receiver, as shown by the dotted lines. The former layout allowed water and other foreign matter to collect and plug up the pipe.

We then turned our attention to the suction line of the compressor, which was piped up in a rather peculiar



Change made in liquid line between condenser and receiver, also layout of suction line to compressor

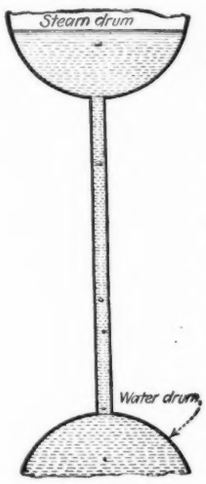
manner. The line should have been the full size all the way, but the section of pipe between the gage connection and the shut-off valve had been reduced about two sizes. Just why this had been done the engineer could not explain. The replacing of the small section of the line with pipe of the proper size made an appreciable difference in the operation of the entire plant and also reduced the current consumption of the motor driving the compressor. R. G. SUMMERS.

Rochester, N. Y.

Comments from Readers

An Experiment in Boiler Settings

Replying to the question asked by A. A. Fette in the Sept. 30 issue, "Has an actual test ever been made to determine if there is any difference in the temperature of the water in a boiler at the surface of the water and at the bottom? If so what did it show?" I have sufficient confidence in the steam tables and in the research work performed by scientists to believe that a steam bubble in the bottom of a boiler is hotter than a steam bubble at the top of the same boiler.



Relative size of steam bubbles

The accompanying illustration is intended to show the relative size of a steam bubble at different points of a vertical boiler having horizontal drums. At the bottom, a steam bubble is under maximum pressure, and according to our steam tables the temperature will be highest because the pressure surrounding the bubble is equal to the steam pressure in the same space plus the pressure due to the static weight of the water. When the bubble reaches the surface of the water the pressure is equal only to the steam pressure, consequently according to steam tables the temperature will correspond with the pressure and be lower than when it was at the bottom of the boiler.

Referring to the baffle construction shown in Mr. Fette's letter, I do not consider the effect of the baffle worth while, because the difference in temperature can hardly be sufficient to warrant the expense. Further, the engineer who planned the setting had the wrong idea if he wanted to bring the lowest-temperature gas in contact with the lowest-temperature water; that is contrary to good engineering thermodynamics.

Elizabeth, N. J. L. W. LOWERRE.

[Results of actual measurements of the temperature difference in different parts of a boiler are given in the article "Temperatures in Water-Tube Boilers," page 603, Oct. 14 issue.—Editor.]

New Method of Absorbing Oxygen

With reference to the announcement in the July 22 issue of a "New Method of Absorbing Oxygen," a discovery of Louis F. Fieser, of Cambridge, Mass., we have tried out the new solution, which the discoverer terms "An alkaline solution of sodium hydrosulfite containing two per cent of anthraquinone-β-sulfonic acid as a catalyst," for boiler-room Orsat work and find it highly sasisfactory.

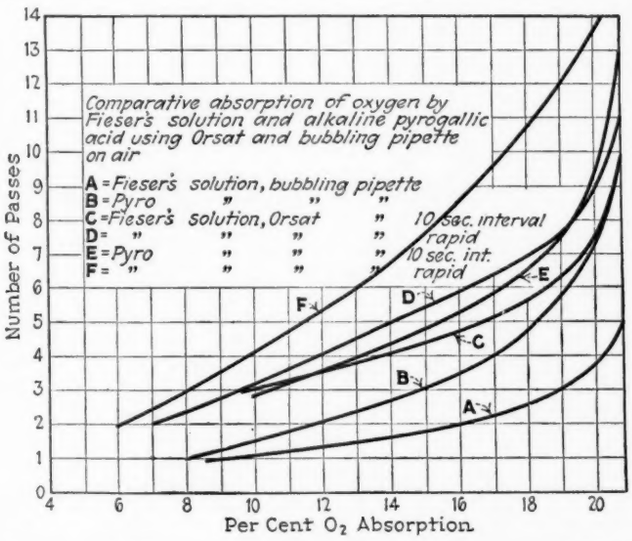
The solution, which is blood red in color and can be readily prepared, is of very low viscosity and the ordinary manipulation by which the gas is kept bottled up in the absorption pipette is not satisfactory. However, repeated pumping of the gas through the pipette or the use of a bubbling pipette will permit speedier and more positive absorption than does the alkaline solution of pyrogallic acid that is most commonly used.

A series of comparative tests were conducted in order to determine the relative speed of absorption of the two solutions and the advantage of using a bubbling pipette as compared to the ordinary Orsat pipette. The accompanying curves are based on average results obtained on air and clearly show the relative action of the solutions and pipettes.

The Fieser solution has a tendency to build up a froth which is troublesome when the last bit of gas is being discharged from the pipette. This froth is less pronounced after the fourth passage of the gas through the pipette, and it is suggested that the first four passes be made without discharging all the gas from the pipette and that the pipette be completely discharged on the fifth pass. Five complete passages of the gas through the pipette will complete the absorption as shown on the curves.

It will be noticed that the Fieser solution is faster than pyragallol. This feature is valuable as it not only saves time, but also discounts the effect of possible leakage of the apparatus, which is a function of time.

The chemicals were obtained from the Eastman Kodak Co. through a chemical supply house, and the cost laid down in British Columbia was ten cents per



Shows relative speed of absorption of the two solutions

gram for the sodium anthraquinone-β-sulfonic acid and 7½ mills per gram for the sodium hydrosulfite. This brings the cost of the solution up to about 80c. per batch of 225 c.c. as compared to about 12c. per batch of pyrogallol. The cost is, however, a small item when compared to the advantage afforded.

Powell River, B. C. M. S. GEREND.

William Stuart Auchincloss—an Appreciation

With reference to the "Foreword" in the Oct. 14 issue which contains so many good and consequently proper words relative to the Rensselaer Polytechnic Institute, I offer the suggested appreciation of William Stuart Auchincloss, born in New York, 1842, graduated as civil engineer from the class of 1862 of Rensselaer. I have never had personal contact with Mr. Auchincloss, but have felt his presence for more than thirty-seven years.

In 1888, while a young boy, I came into possession of Auchincloss' "Link and Valve Motions" and will state that if I am at all educated, Mr. Auchincloss constitutes one very substantial part of the foundation thereto. He presents his subject with a clarity that leaves nothing more for the imagination to demand save an opportunity to demonstrate that he fits his students for attacking valve-gear problems not specifically treated in his book.

As the son of a widow and an apprentice in a machine shop I did not have the advantage of a father's advice as to the inherent deviltry of the self-proclaimed practical man who meets reasoning with demeaning gestures and disparaging language. As a consequence, through my quoting Auchincloss in the shop, I became as popular as the yellow fever.

There is no subject that will more effectively arouse and quicken to action the cussedness of machinists and engineers of the "practical" types, than valve gears.

The men who fit, assemble and operate steam turbines will probably find Auchincloss' subject of less interest than blade erosion, heat balance, dynamic balance of rotors, and oil films between journals and bearings. Also, the Diesel engine is properly receiving much attention, all of which does not obviate the need of men of the power field being attentive to the link-work mechanisms as presented by Auchincloss, as this presentation of the subject fits men to grasp other subjects.

Louisville, Ky. HARRY CORNELL.

Compressed-Air Tank Explosions

With reference to the article in the Sept. 16 issue describing the compressed-air tank explosion at the Service Ice Co., Indianapolis, Ind., I know of several similar cases and was on the ground in the case of one.

In the electric-driven power plant of a large smelter at Copper Cliff, Ontario, was a two-stage air compressor driven by a direct-connected motor and working against about 100 lb. pressure. The plant was of solidly built concrete construction with a high basement. The receiver was hung under the floor, lengthwise with a long passage about 12 ft. wide running the full length of the building. The compressor capacity was regulated by an automatic throttle control on the intake.

One day without any warning the safety valve blew off the receiver. This was replaced and the compressor again put into service. About a week later the receiver, which was 16 ft. long by 4 ft. in diameter, exploded. One end of the receiver was blown clear. It gave way at the top first so that it hinged on the lower side and dropped vertically to the ground. The rest of the shell with the other end intact was blown horizontally 75 to 100 ft. until it hit the concrete foundation wall at the end of the building. The walls of the passage were coated with soot after the explosion.

When it is considered that the receiver was blown that distance without apparently touching sides, top or bottom of a passageway probably not over 12x12 ft. in size, the tremendous force released is appalling. The concrete floor directly above the receiver was about 6 or 8 in. thick and directly above the head which blew out, was left a hole at least two feet in diameter. Peculiar as it may seem, when the explosion occurred many of the large window and door frames in the building toppled over inwardly to the floor.

Right or wrong I have always believed the cause to be due to the throttling method of regulation being used where the compressor was working at below one-quarter capacity. Of course quantity and quality of oil probably contributed. L. G. GATES.

Bakersfield, Calif.

The Master Mechanic

With reference to the article by H. A. Cozzens, Jr., in the Oct. 7 issue, commenting on the "Foreword" in the Aug. 26 issue entitled "The Master Mechanic," he seems to feel that this reflects unfavorably on the master mechanic and does not present him in his true light. From my experience of several years in the engineering line I take just the opposite view.

One of the best-operated plants I have known was one in which the chief engineer and his master mechanic spent over half their time in the office. The operating staff was directly under the chief engineer, but the remainder of the crew, including electricians, repairs men, boiler men, etc., were under the master mechanic. This particular staff was wonderfully well organized, being divided into several groups each with a particular branch of work and responsibility. The equipment was kept in first-class operating order, and there was no dashing around from one section of the plant to the other on the part of the master mechanic. Instead, he found time to study over the problems of his plant in the quiet of the office and not while on his feet, as the writer of the article referred to would have us believe is the modern custom.

The co-operation and harmony that existed between the chief and master mechanic and the entire staff was perhaps exceptional, but it certainly proved to be in the best interests of the plant. I see no reason why the almost ideal conditions that prevailed in this plant should not be the general rule instead of the exception.

On the other hand, the chief engineer or the master mechanic is not always to blame for poor organization, as this may be influenced by someone higher up. In one plant with which I am familiar the superintendent was never satisfied unless the chief engineer was constantly on the move. If he visited the plant, which he usually did once or twice a day, and found the chief engineer in the office, he would at once find fault with some part of the operation or some particular piece of work that was going on. He seemed to think the chief was shirking his duty if he was not constantly on the move.

It has been my experience that the man who has the ability to organize and train his staff so that it is not necessary for him to be constantly moving about and permits him to do most of his planning or thinking in the office or while sunning himself on the doorstep, as pointed out in the "Foreword," is the one who is the most successful. G. R. BROWN.

Chicago, Ill.

Pipe Joints for High Pressures and Temperatures

An article on "Pipe Joints for High Pressures and Temperatures," published in the Sept. 9, 1924, issue is possibly misleading in that a description of the Detroit Edison Co.'s practice in Van Stoning is intermingled with general comments on this style of joint. In order to correct any wrong impression that may have been received from this article, I take this opportunity to present the following further explanation of Detroit Edison practice:

The Detroit Edison specification for high-pressure Van Stone joints reads in part as follows: "In the process of Van Stoning the pipe ends shall be upset sufficiently to obtain a thickness in the turned-over portion, which, after machining, will not be less than the wall thickness of the untreated pipe." The point to be emphasized here is that the pipe end must be upset during Van Stoning enough to leave the lapped flange the full wall thickness of the pipe even after it is machined.

The article of Sept. 9 stated that "reinforcing rings ordinarily are welded to the flanges before machining, so that the thickness of the metal when finished, will not be less than that of the pipe itself." This is distinctly different from the process specified by the Detroit Edison Co., in which the increased thickness is obtained by a rolling of the metal to produce upsetting, rather than in building it up by welding on an extra ring.

The use of Van Stone joints by the Detroit Edison Co. has been limited to the general style illustrated in Fig. 1 of this article, and does not include such modifications as "tongue and groove." The phonograph finish mentioned in a later paragraph is correctly described as a "spiral or concentric ring effect, the pitch of which shall not exceed $\frac{1}{32}$ in. radially, and the depth not to be over $\frac{1}{64}$ in."

SABIN CROCKER.

Detroit, Mich.

Driving the Boiler Auxiliaries in the Small Plant from a Common Lineshaft

The suggestion of T. J. Quinn in the Oct. 14 issue that in some of the smaller plants a better heat balance and more economical installation could be had by driving the boiler auxiliaries from a common lineshaft is, I think worthy of consideration.

In the plant where I am employed, this scheme has been carried out and works satisfactorily. The boilers, four in number, are equipped with underfeed stokers and independent forced-draft fans. A common lineshaft is carried along the floor just below the stokers, and from it each stoker is driven through a roller chain and each of the forced-draft fans, which are placed below the floor, is driven through a silent chain. Each of the fan-chain sprockets on the lineshaft is fitted with a clutch so that it may be cut out at will. At one end of the shaft a motor is provided as a driving unit, while at the other a vertical engine is installed and connected to the shaft through a clutch. On the other end of the engine shaft is mounted an induced-draft fan which handles the gases from all the boilers. A regulator operated by the varying steam pressure is installed to regulate the speed of the engine, and since the fans and stokers are driven from the same engine, the speed of each is changed simultaneously. In this way the complete firing equipment is co-ordinated and functions as one unit. The feed pump is the only independently driven auxiliary, but I see no reason why a pump of suitable type could not be driven from the shaft with equal results and considerable saving in steam. A plant installed in this manner has several advantages, the most important being the initial cost of the equipment, which is much less than fitting each unit with individual drive. In my opinion, however, this system of driving the auxiliaries has its limitations and is not practical in larger plants, where there are many boilers or where the boilers are of large capacity, for in that case the individual drive for each auxiliary is desirable.

Boston, Mass. J. W. SLOANE.

Steam Discharge Computation

By giving engineers a fairly simple graphical method of figuring steam-flow problems, S. D. Barclay, who wrote the article on the subject in the October 14 issue, has done a real service. I have, however, several comments that may be helpful to engineers interested in the subject. As Mr. Barclay says, his curves are based on Napier's rule, $M = \frac{FP}{70}$, where M is the discharge in pounds per second, F the area of the orifice in square inches and P the initial pressure in pounds per square inch absolute. Figs. 1 and 2 of his article are graphical representations of this formula. As the formula is supposed to apply only to saturated steam and to cases where the absolute back pressure is less than 58 per cent of initial, correction curves are given for superheated steam, wet steam and for back pressure higher than 58 per cent of the initial. These are based on formulas in Marks' Handbook and other books.

To me it seems questionable whether it is worth while to work out all these corrections on Napier's rule, which at best is supposed to be but a rough approximation, a "rule of thumb." Probably the chief use of Napier's equation is to figure roughly the amount of steam wasted through holes of various sizes. For more refined work, such as the design of turbine nozzles, it would seem well to discard Napier's rule and use either the Mollier diagram or the formulas of Grashof or Rateau, which are also given in Marks' Handbook. These formulas, involving logarithms and fractional powers, are harder to figure with than Napier's rule, but if diagrams had once been prepared they would be no harder to use than Mr. Barclay's diagrams for Napier's rule.

Incidentally, it may be mentioned that in applying Napier's rule to expanding turbine nozzles, the area involved is that at the throat where the back pressure automatically adjusts itself to 58 per cent of the initial pressure.

Where any degree of refinement is desirable, why not go back to fundamental principles and work out the flow from the Mollier diagram, taking the velocity as the square root of the adiabatic heat drop multiplied by 223.7? The density of the steam at the throat can also be found from the Mollier chart, and this combined with the throat velocity gives the proper area for a given discharge, or vice versa. Readers who are interested can find a clear explanation of this method and of a similar method for expanding nozzles (with allowance for friction) on pages 366 and 367 of Marks' Handbook.

N. J. RIPLEY.

Providence, R. I.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Temporary Forcing of Water Tube Boilers

One of our water-tube boilers, which has 6,000 sq.ft. of heating surface and is hand fired, supplies steam for vulcanizers. We carry 125 lb. gage pressure, but the demand on the boiler is irregular, due to supplying steam for three or more vulcanizers at the same time. Often there is enough steam to bring the pressure in the vulcanizers temporarily up to 60 lb. and practically no steam the next moment, making it difficult to maintain the pressure within 15 to 30 lb. of the desired amount. What would be the best method of draft control for the boiler to reduce the trouble to a minimum? D. R.

If the necessary pressure cannot be restored quickly enough with the maximum draft of the chimney, the boiler should be supplied with a forced- or induced-draft fan directly connected to an engine or turbine whose steam supply is automatically controlled by the pressure of steam in the boiler that supplies the vulcanizers. To insure quick generation of steam, it will be necessary to carry a high level of water and clean and rather thick fires, in order that heat from the furnace may be built up rapidly to meet the temporary forcing of the boiler when necessary.

Calibrating Steam Consumption

In figuring the steam consumption of our various departments, we have tried to carry our calculations back to the coal pile, and find difficulty in assigning the proportion of steam supplied to air compressors. We have a steam-flow meter, but are advised by the manufacturers not to use our steam-flow meter on a reciprocating engine. How can we estimate the steam used by three air compressors, one of which is 8x8x8 in. operated without a governor, one of the same size has a throttling governor and one 12x10x10 in. is equipped with a flywheel governor, and its steam supply is controlled by an unloader and steam regulator? E. Z. S.

Although a steam-flow meter may not be adapted to measuring the steam used by individual compressors, fair results should be obtainable by measuring the flow through a steam line which supplies all compressors at the same time. If this cannot be done, place a diaphragm, made of saw plate, in the main steam supply line with an aperture only large enough to supply the maximum requirements and have a good steam gage placed on the line on each side of the aperture. Then, during a day when the compressors are in regular operation, make half-hourly observations of the pressure indicated by each gage. Subsequently, by means of a steam-flow meter, the flow under any of the observed pressure conditions can be measured when blowing the steam to waste through a valve on the discharge side of the aperture for the purpose of holding up the discharge pressure to the desired amount. If a steam-flow meter is not available for calibrating the flow, have the discharge to the atmosphere take place through another aperture in a thin plate made only large enough for the least difference of pressure to be calibrated. Note the pressure of steam supplied to the discharging aperture and diameter of that aperture and make a series of tests with the diameter of the discharging aperture enlarged sufficiently to obtain one after another set of pressure conditions previously observed on each side of the first aperture, each time noting the size of the discharging aperture and the steam pressure presented. Then, for any given set of original observations the flow taking place through the discharging aperture can be computed by Napier's approximate formula, "Flow of steam in pounds per second = absolute pressure × area of discharging aperture in square inches ÷ 70."

Conversion of Metered Volume of Gas to Volume at a Standard Pressure

We use natural gas as fuel under our boilers, metered at an average pressure of 9 lb. gage. The pressure on which the gas company's rate is based is 4 oz. gage, and to reduce the metered volume to this standard they multiply the metered volume by the factor 1.59726. From this it would appear that natural gas does not follow Boyle's law for a perfect gas, which for 9 lb. gage, or 23.7 lb. absolute, would give $V_1 = 23.7 \div (14.7 + \frac{4}{16}) = 1.58528$. *How is the factor 1.59726 obtained? S. T. H.*

Boyle's law is: "The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure which it bears."

However, this is not exactly true of actual gases. The volume of air, for instance, always diminishes a little more than is required by Boyle's law. In the natural-gas industry a standard set of conditions has been adopted, the temperature being 60 deg. F. and the pressure 4 oz., or ¼ lb. above an assumed mean atmospheric pressure of 14.4 lb. per sq.in. This is equivalent to 520 deg. F. absolute, and 14.65 lb. per sq.in. absolute, and to change the conditions of a gas from any given set of conditions to those considered standard, the gas is assumed to act in the same way as a perfect gas. Accordingly, 9 lb. gage would be taken as 9 + 14.4 = 23.4 lb. per sq.in. absolute and 4 oz. pressure would be taken as $\frac{4}{16}$ + 14.4 = 14.65 lb. absolute. Then, to reduce a volume metered at 9 lb. gage to the volume at 4 oz. per sq.in., the factor would be 23.4 divided by 14.65 = 1.59726, as used by the gas company.

Required Diameter of Water Cylinder of Duplex Pump

What would be the required diameter of the water cylinders of a direct-acting duplex steam pump, to deliver 1,000 gal. of water per minute where the length of stroke is 14 in., speed 50 r.p.m. and allowable slippage 3 per cent? *J. A. F.*

Pumping 1,000 gal. per minute would make 1,000 × 231 = 231,000 cu.in. of water per minute, and with 50 r.p.m. of the pump each side of the pump would have to deliver one-half of 231,000 ÷ 50, or 2,310 cu.in. of water per minute. Allowing 3 per cent slippage, the actual piston displacement for one side of the pump would have to be 2,310 ÷ 0.97 = 2,381.4 cu.in. per revolution. A 1¾-in. diameter piston rod has a cross-sectional area of $1\frac{3}{4} \times 1\frac{3}{4} \times 0.7854 = 2.4$ sq.in., and with 14-in. stroke the rod reduces the piston displacement in one cylinder 2.4 × 14 = 33.6 cu.in. per revolution. Hence to compensate for the rod the gross piston displacement of each side of the pump must be 2,381.4 + 33.6 = 2,415 cu.in. per revolution, or for each side of a piston 2,415 ÷ 2 = 1,207.5 cu.in., requiring a gross piston area of 1,207.5 ÷ 14-in. stroke = 86.25 sq.in., which corresponds closely to the diameter 10½ in., or more exactly

$$\sqrt{\frac{86.25}{0.7854}} = 10.48 \text{ in. diameter.}$$

Utilizing Exhaust Steam for Heating

In a plant consisting of turbo-generators and reciprocating air compressors, both operating condensing, the major part of the auxiliary machinery is steam driven, exhausting against a back pressure of less than 5 lb. The auxiliary exhaust steam is used to heat the boiler-feed water in open heaters, and such exhaust steam as is not used to heat feed water is discharged to the atmosphere. The feed-water heaters are designed for a maximum pressure of about 1 lb. gage. A large amount of steam is required for heating and now is supplied at 165 lb. pressure through pressure-reducing valves. The pressure which it is necessary to maintain on the heating system varies from 10 to 25 lb. Is it practical to use an injector to force the exhaust steam of auxiliaries into the heating mains by means of the high-pressure steam? *F. S. P.*

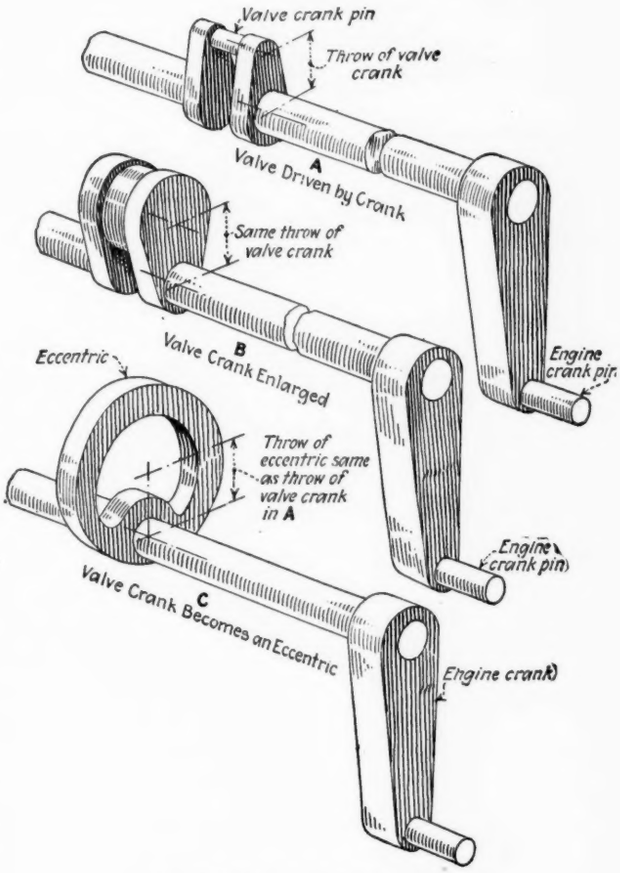
An injector could be used to deliver high-pressure steam to a heating system at a reduced pressure, and also drag along lower-pressure steam, but the arrangement is not practical for use in heating apparatus, since it would need to be adjusted frequently to the varying conditions. When the heating system is satisfied, it will refuse to receive any more steam unless blown to waste. With the high pressure continuing, the only outlet would be back to the low-pressure exhaust, and there would be a building up of back pressure with waste of live steam through the "injector" and thence through a back-pressure relief. Otherwise the back pressure might build up to the high pressure of steam supplied to the "injector."

A better method would be to discharge the exhaust of the air compressors and auxiliaries to the heating system with 10 to 15 lb. back pressure, and if it is not enough for the heating, supplement it with 165-lb. steam supplied through a reducing valve at the lowest pressure appropriate for the heating. Then with a back-pressure relief valve in the exhaust of the auxiliaries set at 15 lb., the relief never would be open to the atmosphere when the reducing valve was open for supplying live steam at 10 lb., and on the other hand, the auxiliaries never would be subjected to more than 15 lb. back pressure.

Eccentric Equivalent to Crank

What determines the amount of movement of the center of an eccentric on each side of the shaft on which it is mounted? *R. N. C.*

An eccentric is a crank in which the crankpin is made large enough to include the shaft on which it is mounted. Just as the travel of the center of a main crankpin on each side of the center of the shaft is equal to the throw or radius of the crank, measured from the center of the shaft to the center of the crankpin, so the travel of the center of an eccentric on each side of the shaft is equal to the throw or eccentricity of the eccentric, which is the distance from the center of the shaft to the center of the eccentric sheave.



Eccentric Equivalent to Crank

If a valve is driven by a double crank with a small valve crankpin, as shown in the sketch mounted on shaft *A*, then there would be the same travel obtained with the same throw of crank with an enlarged crankpin, as shown mounted on shaft *B*. In the same way if the crankpin diameter is so much enlarged as to surround the shaft, the crankpin becomes an eccentric sheave, as shown mounted on the shaft *C*. Then if the throw or eccentricity of the eccentric is the same as the throw of the double crank on shaft *A* or shaft *B*, the travel of the center of the eccentric on each side of the shaft, and travel imparted to the valve rod, will be the same in each case.

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

Solution of a Combustion Problem

THE following question was recently received by *Power:* "A mixture of methane, carbon monoxide and hydrogen is burned in oxygen. In the operation 54.5 volumes of oxygen are consumed and 29 volumes of CO_2 are produced. The total contraction is 62.5 volumes. What were the original volumes of methane, carbon monoxide and hydrogen?"

While this problem is of some general interest (it illustrates a method of gas analysis whereby these three gases may be determined by burning or exploding with oxygen) the answer was altogether too long for use in the columns of the "Questions and Answers" department. It is therefore presented here.

We may start by writing the equations for the combustion of methane (CH_4), carbon monoxide (CO) and hydrogen (H_2):

(1) $CH_4 + 2O_2 = CO_2 + 2H_2O$
1 vol. + 2 vol. = 1 vol. + zero vol.

(2) $2CO + O_2 = 2CO_2$
2 vol. + 1 vol. = 2 vol.

(3) $2H_2 + O_2 = 2H_2O$
2 vol + 1 vol. = zero vol.

The relative volumes indicated in the foregoing are worked out on the basis that a molecule of any true gas occupies the same space as that of any other gas. Thus, the number of each kind of molecule in the equation is also the "parts by volume." This does not apply to the H_2O (water vapor), which condenses in the gas-analysis instrument and is therefore assigned a volume of zero.

To get the required answer from the data will require a little algebra.

Let A = amount of CH_4
B = amount of CO
C = amount of H_2
Then:

(4) $54.5 = 2A + \frac{1}{2}B + \frac{1}{2}C$

That is to say, the oxygen consumed is twice the volume of CH_4 plus half the volume of CO plus half the volume of H_2. This must follow from the relations shown in equations (1), (2) and (3).

Similarly:

(5) $29 = A + B$

(6) $62.5 = 2A + \frac{1}{2}B + \frac{3}{2}C$

It may not be quite clear how equation (6) was obtained, so a little explanation is in order. Look at equation (1). The total volume of everything at the start is 3. At the finish it is 1, so the reduction in volume (contraction) is 2 for each volume of CH_4. Taking the next equation, (2), 3 volumes shrink to 2 volumes, a contraction of 1 volume for each 2 volumes of CO, hence the $\frac{1}{2}B$. Finally, in equation (3) 3 volumes shrink to nothing, so the contraction is $\frac{3}{2}C$ (that is, 3 volumes for each two volumes of H_2).

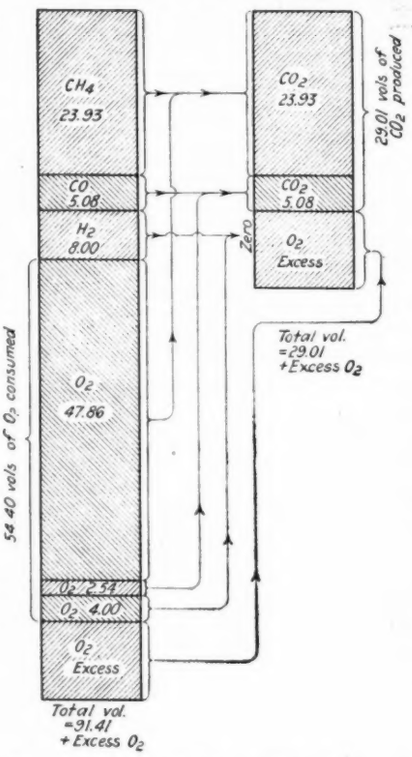
The next step is to assemble the three equations (4), (5) and (6) and solve them simultaneously for the three unknowns, A, B and C.

(4) $54.5 = 2A + \frac{1}{2}B + \frac{1}{2}C$

(5) $29 = A + B$

(6) $62.5 = 2A + \frac{1}{2}B + \frac{3}{2}C$

Before starting to solve these equations, it might be well to review a few



Showing graphically what happens when the given mixture of gases is burned

principles of algebra, which may be stated as follows:

An equation is a statement that one thing equals another.

Simultaneous equations are equations that are true at the same time.

One equation will determine the value of one unknown. Two are needed for two unknowns, three for three unknowns, etc.

If equals are subtracted from equals, the results are equal.

If equals are added to equals, the results are equal.

If equals are multiplied by equals, the results are equal.

If equals are divided by equals the results are equal.

Hence simultaneous equations may be added, subtracted, divided or multiplied and the result will still be true.

To solve the three equations (4), (5) and (6), nothing is needed but these principles and a little ingenuity. The three equations are simultaneous, because they are all true at the same time. There being three equations, it should be possible to get out of them the values of A, B and C.

Note that two terms in (4) and (6) are exactly alike. Subtraction will get rid of them. Write down equation (6), below it equation (4) and then take the difference, thus:

(6) $62.5 = 2A + \frac{1}{2}B + \frac{3}{2}C$

(4) $54.5 = 2A + \frac{1}{2}B + \frac{1}{2}C$

(7) $8.0 = C$ (difference)

or

(8) $C = 8$

Putting this value of C in equation (4) gives:

(9) $54.5 = 2A + \frac{1}{2}B + 4$

or, subtracting 4 from both sides:

(10) $50.4 = 2A + \frac{1}{2}B$

Now we have an equation containing only A and B, as is true of (5). Multiply both sides of (10) by 2, which gives

(11) $100.8 = 4A + B$

Subtract from this

(5) $29 = A + B$

and get

(12) $71.8 = 3A$

or, dividing by 3

(13) $A = 23.93$

Putting this value of A into (11) gives

(14) $100.8 = 95.72 + B$

or

(15) $B = 5.08$

Bringing together the answers obtained from (8), (13) and (15), we have:

Methane = 23.93 volumes
Carbon monoxide = 5.08 volumes
Hydrogen = 8 volumes.

Result Easily Checked

Now, as a final check on this, we may figure out as in Table I what would happen if these volumes were consumed. The factors in columns (3), (4) and (5) have already been explained. Columns (6), (7) and (8) are obtained by multiplying column (2) by columns (3), (4) and (5) respectively.

TABLE I—CHECK COMPUTATIONS TABULATED

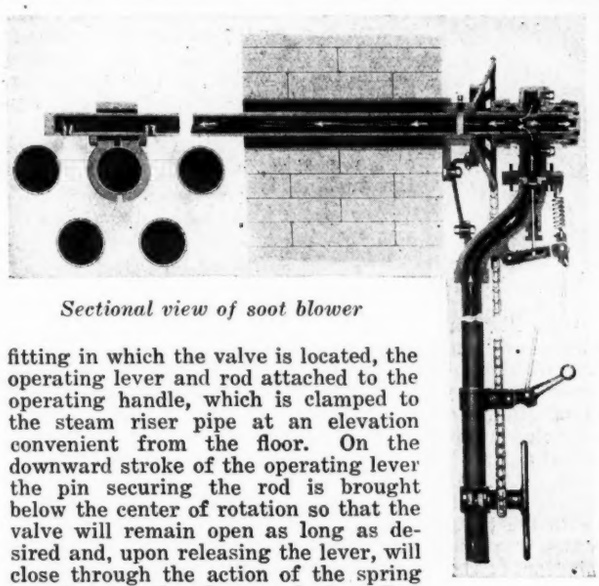
(1) Gas	(2) Vol. Burned	(3) Factor for O_2	(4) Factor for CO_2	(5) Factor for Contraction	(6) O_2 Used	(7) CO_2 Produced	(8) Contraction
CH_4	23.93	2	1	2	47.86	23.93	47.86
CO	5.08	½	1	1	2.54	5.08	2.54
H_2	8.00	½	0	1	4.00	....	12.00
Total					54.40	29.01	62.40

This is a very good check. The small differences are due to the fact that the value of A in equation (13) was not carried to more decimal places.

New and Improved Equipment

New Marion Valve-in-Head Soot Blower

The illustration shows the design of the new Type AB soot blower of the valve-in-head type, developed recently by the Marion Machine, Foundry & Supply Company, of Marion, Ind. The sectional illustration shows the offset



Sectional view of soot blower

fitting in which the valve is located, the operating lever and rod attached to the operating handle, which is clamped to the steam riser pipe at an elevation convenient from the floor. On the downward stroke of the operating lever the pin securing the rod is brought below the center of rotation so that the valve will remain open as long as desired and, upon releasing the lever, will close through the action of the spring attached to the flange of the offset fitting and the steam pressure behind it. The valve is either fully open or closed so that full steam pressure is available during the entire blowing period. The element is revolved by the handwheel clamped to the riser pipe immediately below the operating lever.

The new valve is made of phosphor bronze or monel metal and may be either of the flat type or cone shaped. It can be applied to the former type A soot blower of the company without change of piping. It will be seen that the element has the balanced head feature and the internal welded venturi nozzles through which the steam passes at high velocity to remove the soot from the boiler tubes, common to the type A soot blower of previous design.

Torsion Meter for Measuring Loads Transmitted by Shafting

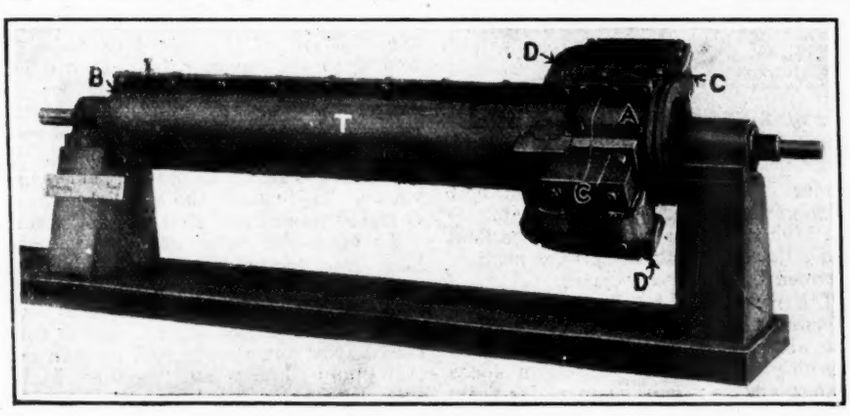
For measuring shafting loads the Cambridge Instrument Co., Inc., Grand Central Terminal Bldg., New York City, has recently placed on the market what is known as a Moullin torsionmeter. The principle on which the instrument operates is the converting of the instantaneous torsion of the shaft into an alternating electric current, each peak of the current curve being proportional to the instantaneous torque. Changes in this current are either recorded by means of an oscillograph (in which case a curve drawn through the tops of the peaks gives the torsion curve) or indicated on an ammeter which can be calibrated to give direct readings of the mean integrated torque of a selected length of shaft.

Two suitable saddle pieces are rigidly secured to the shaft at a fixed distance apart. One saddle piece at *A* carries a U-shaped laminated magnet core *C* on which are placed magnet coils. An alternating current is supplied to these coils from a generator which gives an electromotive force bearing a constant ratio to the frequency. The second saddle piece at *B* carries a tube *T*, which extends (concentric with the shaft) to the first saddle, where it is supported suitably, with freedom to turn on the shaft and where it carries a laminated U-shaped armature *D*. This armature is situated close to the free ends of the magnet core carried by the first saddle. A magnetic circuit is thus set up through the armature and core with only comparatively small air gaps between them. The construction is such that when any torsional movement of the shaft takes place between the two saddles, the armature is moved either farther away or nearer to the core. Variations in the air gaps give rise to variations in the alternating current supplied to the winding on the core.

By making the core and armature of iron of high permeability and by selecting a suitable flux density, the reluctance of the iron part of the magnetic current may be neglected compared with that of the air gaps. Further, by arranging that the size and shape of the air gaps are suitably proportioned to the size and shape of the polepieces and by keeping the ohmic resistance of the circuit as low as possible, the alternating current in the winding will be proportional to the length of the air gaps and thus proportional to the torsional movement of the length of shaft between the supporting saddles. To avoid errors due to bending in the shaft, two armatures are used facing opposite ways at opposite sides of the shaft.

If it is desired that the instrument shall measure power instead of torque, the source of current is so arranged that the current is proportional to the product of the speed of the shaft and the torsional displacement.

Indicating and recording outfits are supplied for 4-, 6-, 8-, 10-, 12-, 14-, and 16-in. shafts, each size being suitable for shafts of intermediate lower size.



Assembly of Torsionmeter

Cash Improved Fan Engine Regulator

A new fan-engine regulator controlled by the varying boiler pressure and designed to bring about compen-

Pressure change is made by moving valve along lever

sating changes in the fan or blower speed smoothly and evenly, is a recent development of the A. W. Cash Co., Decatur, Ill.

The boiler pressure is connected to

the underside of a diaphragm which is counterbalanced by a weighted beam that transmits the pressure change impulses through a link to a balanced valve, connected in the steam line.

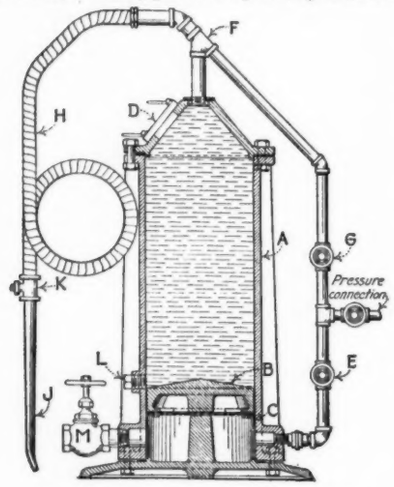
Provision is made for regulating the amount of valve travel for a given change in pressure by shifting the valve along the positioning pad *A* and connecting the link to the beam at the proper point. In this way a definite fixed amount of valve travel is established in relation to a desired change in the boiler pressure.

For saturated steam service the valve is made of bronze except sizes 2- and 2½-in., which are of iron, bronze mounted. For superheated steam the valve body is steel, monel mounted.

The Acme Plastic Sprayer

In the illustration is shown a portable sprayer for the coating of furnace walls, brought out by the Co-operative Utilities Co., Inc., Philadelphia, Pa.

The sprayer consists of a cast-iron cylinder *A*, containing a piston *B* with a conical head, packed by a cup-leather



Section through plastic sprayer

washer *C*. Pressure is applied to the bottom of the piston through piping controlled by the valve *E*. As the piston rises, the mixture is forced into the Y-connection *F* from which point it is forced onward by the combined pressure of the piston and pressure through the valve *G*.

The material is carried through a flexible hose *H* to the nozzle *J*. With certain thin mixtures it is desirable to furnish pressure near the nozzle, and for this purpose an ejector *K* is inserted in the line. A drain plug *L* is provided just above the piston and a second drain releasing the pressure in the bottom at *M*.

The sprayer is designed to handle the standard refractories whenever the nature of the work will allow the use of bonding material and water to form a plastic mass. Air, steam or water may be used to furnish pressure for operating the sprayer. A charge for the machine is about 2½ cu.ft., which is sufficient to cover over 100 sq.ft. with a coat ¼ in. thick. The machine can be carried around the plant on a hand truck, its total weight being about 600 pounds.

Meachem Speed Reducer

The Meachem Gear Corp., Syracuse, N. Y., has recently taken over the manufacture of a speed-reducing mechanism previously known as the Bennington speed reducer. The apparatus is adapted for the transmission of power from high-speed turbines or motors to low-speed machinery such as compressors, refrigerating machines, pumps and similar units.

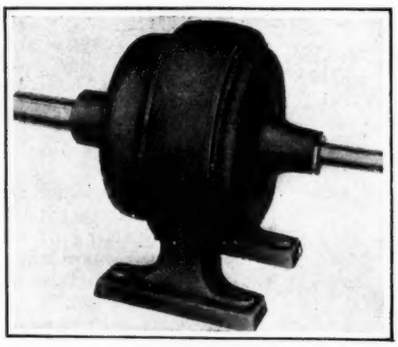


Fig. 1—Reducer is totally inclosed

The reducer is shown in the illustrations, Fig. 2 showing the details of construction. The load is transmitted from the high-speed shaft through planetary gears to a slower rotating ring. A number of rockers are connected inside the ring and engage with a spider keyed to the low-speed shaft. As the driving turbine or motor starts up, each of the rockers engaging with the teeth of the spider first compresses a spring plunger, which brings the bottom of the rocker into contact with the inside of the annular ring and its side into contact with the side of the adjacent spider tooth. The spring plungers tend to prevent starting shock and backlash.

The low-speed shaft to which the

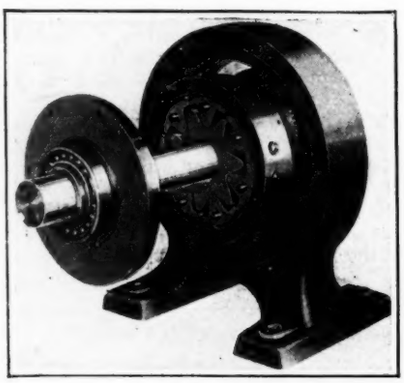


Fig. 2—Arrangement of internal mechanism

spider is keyed is supported on both sides of the spider, while the pinion on the high-speed shaft is allowed to float and adjust itself to the proper position between the planetary gears.

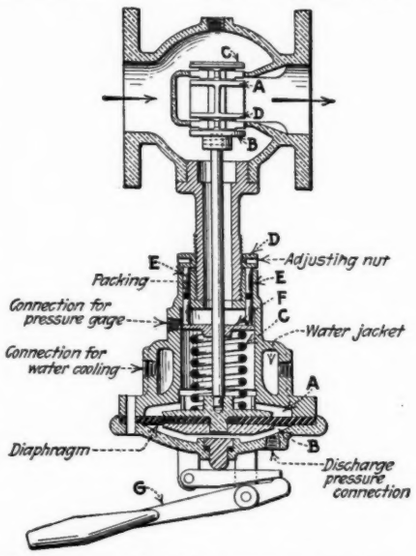
The reducer is totally inclosed, and all parts run in oil with forced lubrication above 1,800 r.p.m. It is designed for either step-up or step-down speed change and is furnished in ratios from 4 to 1 up to 200 to 1 and for any load up to 500 horsepower.

Coppus Combination Governor for Turbine-Driven Feed Pumps

A type of pump governor for turbine-driven centrifugal boiler-feed pumps, in which the excess-pressure governor and safety stop have been combined in one valve, is a recent development of the Coppus Engineering Corp., Worcester, Mass.

The governor consists essentially of a double-seated balanced valve, controlled by a diaphragm, as shown in the illustration. The steam to the turbine flows through the valve in the direction indicated by the arrows. The chamber *A* on top of the diaphragm is subjected to the full steam pressure, while the chamber *B* below the diaphragm is connected with the pump-discharge pressure.

In normal operation the amount of steam passing through the valve to the turbine is controlled by the two



Governor maintains excess pressure on feedline and also functions as a safety stop valve

disks *A* and *B*. The excess of the discharge pressure over the steam pressure is equal to the tension of the spring *C*. When the adjusting nut *D* is turned down, the pins *E* press down the washer *F*, thus increasing the tension of the spring, with a corresponding increase in the excess pressure.

An important feature of this valve is the addition of the auxiliary disks *C* and *D* to the steam valve. It will be readily seen that should the water supply fail for any reason, in which case the discharge pressure disappears, the steam pressure and the tension of the spring *C* force the diaphragm downwards. This causes the auxiliary disks *C* and *D* to seat and shut off the steam.

To open the valve after the pump has been standing idle or in an emergency shutdown, the lever *G* is provided. By drawing the lever downward, the auxiliary disks *C* and *D* are raised from their seats, and as soon as the pump builds up pressure high enough to balance the pressure on the top of the diaphragm, the lever is released.

Ice Problems at Hydro-Electric Plants

AT THE fall meeting of the American Society of Civil Engineers, held in Detroit, Oct. 22 to 25, a session was allotted to the power division to discuss the work of the Committee on Ice Problems at Hydro-Electric Plants. In his paper on the St. Lawrence project, Francis C. Shenehon had made some reference to ice troubles on the Niagara and St. Lawrence Rivers. The importance of ice in a great power stream such as the Niagara might be visualized when it was stated that a minimum flow of 80,000 sec.-ft. was needed, not to preserve the scenic beauty of the Falls, but to pass the ice through. On the St. Lawrence cover ice and frazil ice had a real effect on the head. During the coming year the Committee had in mind collating data concerning ice engineering as entering into hydraulic development, and with these data as a basis, certain investigations might be undertaken.

How Ice Is Formed

The Committee was fortunate in having present John Murphy, of Ottawa, who in a most interesting illustrated talk drew from his 20 years' experience in fighting ice on the Ottawa and other Canadian Rivers. It was this talk that was used as the basis of discussion. Slides showed the location of snow, clear ice, frazil ice and anchor ice adhering to the bottom of the river. Physical properties of water and the different kinds of ice were summarized and a chart showed how the temperature of the water lagged behind that of the air. When the temperature of the water approached the freezing point, then was the time to expect frazil ice.

Relative to wooden versus iron racks, the former clogged just as readily, as frazil ice would stick to anything, but they were easier to clean. The iron being a better conductor, made ice readily when the water was near 32 deg. F. and the upper portion of the rack exposed to cold air. A remarkable photograph showed what may be expected in the way of ice formation when the racks and concrete structure in contact with the water are exposed to the air and not housed in as they should be. To loosen the ice it was necessary to raise the temperature of the parts in question only 0.001 deg. above freezing. The amount of steam required to do this was remarkably small. Taking a steam reserve plant of 3,000 hp. and a water development of the same capacity, the former consumed 144 tons of coal per day of 24 hours, while one ton of coal would keep the water plant free of ice and in condition to generate power.

Warm Water Comes to Surface of a Stream

A case showing how warm water will come to the top of a stream and keep the water from freezing was that of a cement mill which discharged 8 cu.ft. per sec. of condensing water at 62 deg. F. into a river having a flow of 4,000 cu.ft. per sec. Although the ratio was 1 to 500, the river did not freeze for a stretch of 1¼ miles.

It had been estimated that 144,000,000 times as much water passed down the St. Lawrence River as was turned into ice. Hence, the futility of trying to introduce heat into the water as was attempted in former days, to prevent ice formation.

It was Mr. Murphy's suggestion that on the Committee on Ice Problems there should be a plant operator who has struggled with ice, a hydraulic engineer and an enthusiastic physicist, such as Prof. Howard T. Barnes, whose perfection of the electrical differential thermometer to give precise water temperature measurements had done so much for the hydraulic-plant operator.

IN NORTHERN countries one of the most serious problems to be contended with in the operation of hydro-electric plants is ice in its various forms. In this discussion a number of suggestions have been made as to how ice may be prevented from interfering with plant operation. Among the suggestions are: Heating of the affected parts to 0.001 deg. F. above freezing; electrically heated racks, discharging low-pressure compressed air near the bottom of the forebay; formation of slack water pools; housing and heating the headworks by steam or electrically. Where the method can be applied, the use of compressed air seems to be the most economical in both application and the cost of applying the heat.

John R. Freeman, consulting hydraulic engineer, of Providence, R. I., devoted his remarks principally to nucleation. Experiments had showed that the forming of frazil around some nucleus could be detected, as the color of ice, when rising to the top, was more yellow. He was of the opinion that there was some difference in the crystalline structure of frazil and anchor ice. In certain work for the Aluminum Company of America, at Massena, N. Y., he had designed an electrically heated rack, In accord with foregoing statements he agreed that a small amount of coal or electrical energy was required to prevent frazil.

Thomas H. Hogg, hydraulic engineer, Hydro-Electric Power Commission of Ontario, Toronto, considered the problem of ice in power plants, by dividing up the various formations of ice that gave rise to difficulties in operation, and discussing these several varieties in their more troublesome forms. One of the most frequent troubles arising from frazil ice was the blocking of racks.

Where means cannot be taken to prevent the formation of frazil ice and its deposit on the racks, and in cases in northern latitudes where the racks are carried on supporting structures, these latter always should be designed to withstand the full head that might come from complete blocking of the racks. Thus a blockage from frazil ice can only result in a shutdown until such time as the blocked screens can be removed or the broken section of rack replaced, whereas the failure of the supporting structures may mean a shutdown of the entire plant for a considerable period.

Preventing Accumulation of Frazil Ice

Various means for preventing the accumulation of frazil ice on racks have been tried, one of them being the passing of steam through hollow rack bars to keep the metal slightly above freezing temperature. This has met with only small success, as the openings in the rack bars tend to block up and the steam pipes to leak, causing an excessive use of steam and cold portions of rack to which the frazil ice adheres. Another expedient for warming the racks has been the passing of a current through them, but this also, as well as the use of wooden racks' has been found to be only partly successful. In all northern latitudes, if built in the open, the tops of the racks should, of course, be kept below low-water level, or a building that can be heated to a few degrees above freezing placed over the rack openings. This is effective in preventing rack blockage.

In some plants the pulling out of the racks during the time of frazil ice has been resorted to, but this method subjects the turbines to the danger of any foreign matter that may be in the stream. The best means of preventing trouble from frazil or other forms of ice is, in Mr. Hogg's opinion, a large head-water pond with a low velocity, which will freeze over in winter time. If such a condition can be secured, no trouble from ice need be expected, even in the extreme northern latitudes. Protection is afforded by the ice acting as an insulator proper, also heat waves of the comparatively long length resulting from the low temperature of the radiating water cannot readily pass through the ice into the colder air, whereas the short heat waves coming from the high temperature of the sun can readily pass through into the water. This protective ice cover was undoubtedly the best means of avoiding ice troubles during winter operation, and he did not know of a single instance of a plant so situated having any difficulty from ice.

Various means of preventing the entrance of anchor ice into the turbines had been employed, such as ice skimmers, leading to a chute or other disposals, curtain walls, overflow walls. Another expedient was the use of a series of gathering tubes on the river bottom by means of which the water required is withdrawn from over a large area with such a small downward velocity that the suction is not suffi-

cient to overcome the buoyancy of the floating ice. This type of intake in conjunction with the usual curtain wall is equally effective against cake or bordage ice, which is perhaps the greatest source of trouble on the Niagara River.

Preventing the Jamming of Floating Ice

Good results in preventing the entrance of floating ice have been obtained by the use of booms for deflecting the surface water and ice away from the intake mouth. This method requires for success, a fortuitous direction of wind or currents, since if these tend constantly toward the boom, the ice will pile up and force its way under.

One method of preventing the jamming of this floating ice is the use of tugs or ice breakers to maintain an open channel down which the ice can flow with the current or be carried along by sweeps or drags to a chute or overflow arranged for its disposal. As a means of preventing the formation of, or breaking of, an ice jam, there appears to be considerable possibilities in the introduction of heat in the form of warm water, immersion heaters or of rheostats.

Gardner S. Williams, consulting engineer, of Ann Arbor, Mich., referred briefly to his experience on the Huron River in obviating constantly recurring damage from ice carried along at high velocity owing to a drop of 180 ft. in 30 miles. A series of slack-water pools so cut down the velocity that little damage is now experienced from ice. This treatment was recommended for the St. Lawrence River. If along with the development slack-water pools were created, each one reaching back to the tailwater of the one above, little trouble need be anticipated from ice.

Eliminating Ice Troubles at Spillways

James S. Bowman, hydraulic engineer with Fargo Engineering Co., Jackson, Mich., gave some interesting information on eliminating ice trouble at spillways caused by the direct thrust of the ice field, which may seriously damage the gates and runways, or from the freezing of ice on the upstream faces of gates and on piers, which interferes with spilling and necessitates an extra crew to put the gates in operating condition at the time of the spring break-up.

Aside from attempting to cut the ice away when it became imperative to do so, the general method of attack had been to apply heat to the affected parts in one of the following forms: By steam direction against the ice by portable pipes or supplied to a steam chambers built on the face of the gate, or into the piers along the line of gate travel; by the insertion of electrical space heaters in a housing against the downstream face of the gate; by the discharge of air under low pressure just upstream from the gate at sufficient depth to cause the warmer water at the bottom of the stream to be carried upward along the gate to prevent freezing.

The common method of using steam, the speaker said, is to force live steam through a pipe or nozzle against the ice. This process is wasteful of heat, slow and requires a great deal of labor and physical force, but is perhaps the only method of handling the situation where the gates have been frozen all winter and no other equipment is available.

By building steam chambers against the downstream face of the gate and into the face of the piers along the line of gate travel, steam can be applied in an economical manner. However, where temperatures are low and the winter season long, steam must be supplied continuously if trouble is to be avoided in the spring. It has been found at plants of the Consumers Power Co. in Northern Michigan that about 15 tons of coal is required per gate for continuous winter operation. The boiler capacity used in these plants for Tainter gate heating is 150 sq.ft. of steam making surface for one gate 25x13 ft. in size. However, when one gate has been opened the remainder soon thawed by the current set up. The practice at these plants is to add enough additional capacity to the low-pressure power-house heating plant to take care of the gates.

Heaters Installed On Tainter Gates

In 1923 space heaters were installed in four Tainter gates at the Jim Falls Dam on the Chippewa River in Wisconsin. These gates are each 16 ft. wide and 12 ft. high. A housing was built on the downstream side on a chord of the curved face and about two feet therefrom, entirely inclosing the space between, at sides, top and bottom. The housing consisted of two layers of 1-in. sheathing with a layer of bituminous composition roofing between. Four 500-watt space heaters were placed along the bottom of each gate and wired to a receptacle at the top of the gate. A conduit was fastened along the runway with receptacles at each gate and these were connected to those on the gates.

The cost of this installation was $170 per gate, the space heaters alone costing $11, plus a small installation cost. They will probably have to be renewed every three years on account of corrosion in the damp location. The cost of operation at 1c. per kw.-hr. is about 50c. per gate per day, or approximately $50 per annum. Under severe winter conditions the heaters proved satisfactory and gates were kept free of ice. Under isolated conditions where frequent inspection is difficult, electrical heating may be found preferable to other methods.

Compressed Air Used To Prevent Ice Formation

The first systematic use in America of compressed air to circulate the warmer water at the bottom of a stream to the surface to prevent ice formation was at Keokuk. The gates there are of the vertical lift type, 30 ft. wide and 11 ft. high. The expansion of the thick ice in the pond developed a force which buckled several of the gates, and threatened more serious damage. It was found that discharging 1 cu.ft. of air per minute, 10 ft. under water, and 2 ft. back from the center of the gate, would keep an area of open water in front of the middle two-thirds of the gate, or enough to prevent damage. Great care was taken not to thaw the ice from the piers which held the ice field back from the gates.

To furnish this air a main beginning with 3-in. diameter, and ending with 1¼-in. diameter was run along the spillway bridge. At the center of each gate opening was placed a ¾-in. needle valve and a union to which was attached a ¾-in. aëration pipe. This pipe, which is in place only during the winter, is about 18 ft. long and hangs free, ending at the bottom with an upward curve.

Air is compressed at 80- to 90-lb. pressure, passed through a cooler and then through a reducing valve which reduces the pressure to about 15 lb. After this the air passes to a large receiver, which, with all following pipes indoors, is thoroughly insulated to prevent reheating, that being imperative to eliminate moisture in the outside line. All outdoor piping is bare.

The system has been operative at a temperature of 30 deg. F. and has been effective. No trouble has been experienced from freezing in the pipes. With about 2 cu.ft. of air per minute discharged vertically upward at a depth of 18 ft., an area 20 ft. in diameter could be kept open at an air temperature of 0 deg. F. Under the same conditions this amount of air would melt a similar area in ice 20 in. thick in four days. For temperatures below freezing the amount of melting was directly proportional to the quantity of air and the depth at which it was discharged. A change of air temperature changed the open-water area by roughly 3 per cent per degree F., and over the ordinary range of freezing temperatures with 1.72 cu.ft. of air per minute flowing, the rate of thawing is about 3.5 cu.ft. of ice per hour, and the amount is about proportional to the time.

Cost of Preventing Ice Formation

In 1923 a similar air system was installed at the Twin Branch Dam of the Indiana & Michigan Electric Co. from designs of the Fargo Engineering Co., to prevent principally the formation of ice on the upstream face and at the ends and sill. Air is supplied by the compressor at a pressure of 15 or 20 lb. and reduced to a pressure of 5 lb. in the main. Approximately 0.5 cu.ft. of free air per minute was used at each of 14 outlets during last winter. The temperatures during the month of January were low for this locality over a protracted period. Ice formed on the pond to a thickness of 16 in., and at the Elkhart plant, eleven miles upstream, where all conditions are similar, ice form on the face of the gates to a thickness of 12 in. However, the air system was kept in operation at Twin Branch without interruption and with practically no attention, keeping the gates entirely free from ice.

The power required to operate this system was not over 2 kw. for seven gates. At a cost of 1c. per kw.-hr. the cost approximated $0.07 per gate

per day with slight attendance by the operating force.

On the Cedar River at Waterloo, Iowa, there were built in 1923, three sector gates of the drum type with the curved face upstream. The crest height is regulated by water pressure under the gate, and an automatic device adjusts the height to pass the river flow with headwater at normal stage. Each of these gates is 67 ft. long and rises to a height of 8 ft. above the breast wall.

As the curved face of the gates presents a slope of 45 deg. upstream at the water line, there is little to be feared from ice thrust. But in order to prevent ice jams at the bridges downstream, it is desirable gradually to clear the pond of ice in advance of the general breakup above, and this is to be accomplished by manipulation of the gates. Also the gates must be kept in operating condition to maintain headwater at normal at any time the use of water at the power plant decreases. Accordingly, the gates must never be frozen in, and compressed air will be used to prevent this.

Ice Troubles in St. Lawrence

D. W. McLachlan, chairman of the Canadian section of the International Board, closed the discussion that already had gone past the usual time limit. To show that the effects of winter could not be nullified on the entire St. Lawrence River, he pointed out that it would take over 7,000,000 hp. in steam to melt 2 ft. of ice for a 48-mile stretch of the river. On the other hand, enlarged channels to give an ice cover would run into large figures. To obtain a velocity as low as 2 ft. per second would require the expenditure of at least $50,000,000. His experiences on the Trent River were interesting where the plant was located at the foot of nine miles of rapids. There was pond after pond of ice cover, and just at the junction one with the other there would be a little open water at the head of each reach, the area being in proportion to the length of the ice cover above. It was a strange phenomenon caused by the sun's rays passing through the ice to heat the water and the additional heat gained from the velocity of the water.

It was his suggestion that the Committee should have some data on the effect of zero air on flowing water, the transfer of heat from the river bed to the water and the volumetric quantity of frazil formed under various conditions. The International Board was now securing much of this information and it should be available soon in published form.

Electrical engineers in Germany are being forced by the high price of coal to utilize the nation's waterpower resources to the fullest extent. The first hydroelectric plant in the Province of Bradenburg, located at Spremberg, started operating this year. The satisfactory results obtained have led to a survey of other possible power sites in this province and favorable places have been discovered at Wendisch-Buchholt, at Boden near Deichow, and at Lausitzer Neisse.—*Commerce Reports.*

Steam Generation at Extra High Pressures*

By Viktor Blomquist (Stockholm)

THE readiest means of improving economy is to increase the steam pressure as far as possible. The higher the initial steam pressure the greater will be the percentage of the heat energy in the steam transformed into mechanical energy when the steam is allowed to expand down to a certain back pressure.

By increasing the steam pressure from 300 lb. to 450 lb., with a total heat[1] of 1,350 B.t.u. per lb. in each case, the amount of heat transformed into mechanical energy would be increased by almost 5 per cent when the steam is expanded down to 28½-in. vacuum.

If the initial steam pressure be raised to 1,500 lb., the efficiency would increase by 20 per cent with the same initial heat and the same vacuum. The higher the back pressure the greater will be the saving derived from the use of extra-high-pressure steam.

Fig. 1 indicates the available heat of one pound of steam expanding from various initial pressures to various back pressures. The heating value of the high-pressure steam is assumed to be 1,350 B.t.u. per lb. for each of the four curves. It will be seen from this diagram that the advantages of employing extra-high-pressure steam in comparison with steam at ordinary pressures increases considerably as the back pressure increases. Consequently, the extra-high-pressure steam is especially advantageous in industrial plants such

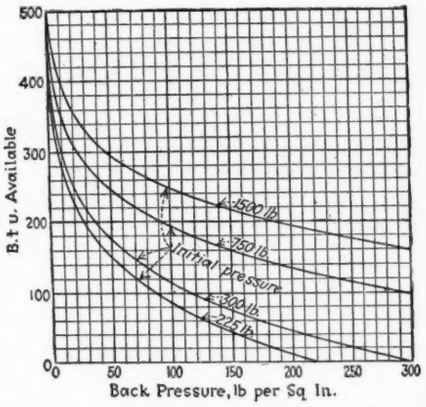


Fig. 1—Diagram showing the marked effect of back pressure upon the gain from higher pressures

as chemical works, sugar refineries, alkali works, etc., which use steam for heating and boiling, as well as power generation.

The power generated by a back-pressure turbine is less expensive than power generated in any other conceivable way, provided all the exhaust steam be used for heating purposes. It is also evident that the economy of any existing steam plant may be considerably increased by adding a high-pressure turbine, exhausting to the present main. Fig. 2 shows the percentage increase of energy that may be obtained from the same fuel consumption as before by the application of an additional turbine working at 1,500 lb. pressure. Allowance has been made for the energy consumed by the high-pressure feed pump.

Objection might be raised to the use of high superheat temperatures at 1,500 lb., since the tubes of the superheater might be expected to burst under such conditions. This, however, is not the case, because of the increased coefficient of heat transmission with the denser high-pressure steam. The temperature of the tubes in such a superheater will be lower than in a superheater working at the same steam temperature under normal pressures. At the higher pressures the tube will be only a few degrees warmer than the steam. This has been proved in practice by experiments with boilers for extra-high-pressure steam up to 3,000 lb., carried out by Doctor DeLaval in the latter part of the nineteenth century. The first Atmos boiler for 1,500-lb. pressure, now working, carries a steam temperature of 890 deg. F. without any trouble.

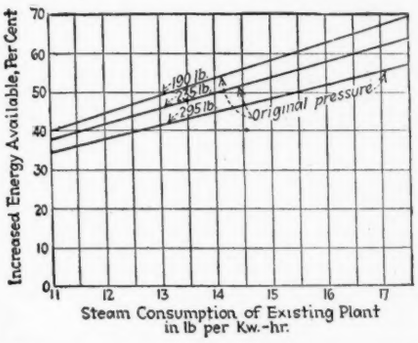


Fig. 2—Increased energy available from same fuel consumption by adding a high-pressure turbine (1,500 lb. pressure)

Further improvements in economy can be produced by bleeding steam for heating feed water. By this means it is possible to attain a thermal efficiency of more than 30 per cent.

In recent years many inventors, including DeLaval, Serpollet, Hereshoff and White, have attempted high-pressure steam generation with coil tubes of small diameter to avoid the risk of explosion. These experiments on the whole have been unsuccessful because of the difficulty of removing scale. The rotating-tube boiler is the practical solution of the problem of high-pressure steam generation.

The principal feature of this boiler is that the steam is generated in rapidly revolving tubes so arranged that they may expand freely without strain. This rotation results in the inside circumference of the tubes being entirely covered with a solid layer of water, which is pressed against the walls by centrifugal force, thus forcing the steam bubbles rapidly from the wall into the open central space.

*Abstract of paper presented at the World Power Conference.

[1]To contain this amount of heat, the steam would have to be superheated to 190 deg. F. at the lower pressure, and 164 deg. at the higher.—Editor.

Installing the Electric Steam-Flow Meter*

BY J. M. SPITZGLASS

ALL fluid-measuring devices consist of two major parts. One is the primary element, which comes in contact with the fluid and is acted upon by its motion, producing a differential pressure proportional to the rate of flow. The other is the secondary element, which translates the action of the fluid upon the primary device (differtial pressure) into rates of flow, weights or volumes, as may be required.

How Velocity Pressure Is Obtained

Fig. 1 shows diagrammatically how a differential pressure is obtained by the commonly used types of primary devices—the pitot tube, the orifice plate, the nozzle tube and the venturi. With any one of these devices inserted into the pipe, the change in velocity produces a corresponding change in the liquid column, balancing the pressure difference between the high- and the low-pressure sides of the device.

At this point it is well to mention that the pressure difference, which is the basic principle of the flow meter, follows the law of squares in its operation; that is, the impact pressure of a given flow is proportional to the square of the velocity of that flow and therefore at low velocities the impact pressure is exceedingly low. It is important to know this in order to determine the desired range of the meter. For this reason the Republic flow meter has been worked out with scales of various sizes, and a meter always can be so

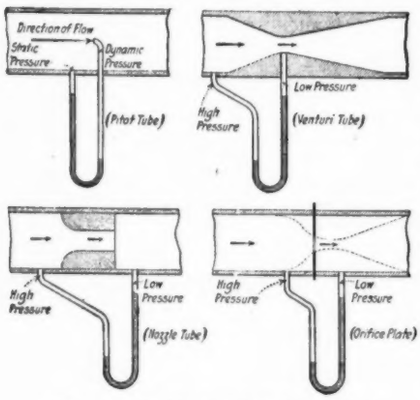


Fig. 1—Methods of determining velocity pressure

chosen that the desired measurement will fall within the active part of the given scale.

In general the pitot tube has the advantage of being easily inserted into the pipe line through a convenient standard tapped opening. It has some disadvantages as compared with an orifice plate, which is the differential medium chiefly employed in present installations. The main disadvantages of the pitot tube lie in the fact that the measurement is obtained at a single point in the section of the pipe. If this section follows a straight length of pipe in the line, the "point" measurement may represent accurately the average velocity in the pipe. If, however, the section follows a fitting or any twist in the line, the "point" measurement will not represent the average velocity, and the readings will not be correct. The pitot tube therefore is used for practical purposes with this restriction in mind.

Another disadvantage of the pitot tube is that its use is limited to a definite range of capacity for any given meter. For instance, a pitot tube may be used advantageously if the velocity of the fluid in the pipe will be of a magnitude that will raise a measureable column of mercury for operating the flow meter. If the velocity is low, the column of mercury raised will be insignificant for measurement. In other cases the velocity pressure may be too high for the range of the measuring device. When medium velocities are obtained, the pitot tube can be used conveniently, but its accuracy always depends upon whether the point measurement actually represents the average velocity in the pipe.

The Close Tap and the Far Tap

In the practical application of the orifice plate differentiation should be made between the close tap with the opening at the smallest area of the jet and the far tap at the section of uniform flow on the low-pressure side of the orifice. It is recommended that the close tap should be used in all cases where the differential pressure does not exceed the maximum head of the meter body. When this opening is used for the low-pressure side, the maximum drop of pressure through the orifice is available as the effective head in the meter body. There are cases where the far tap is utilized to great advantage. If the flow has an original high velocity through the pipe, any restriction will bring about an excessive drop through the orifice. In such cases the restoration of pressure is quite significant and the use of the far tap will bring the differential within the range of the meter body.

Careful consideration should be given to the placing of the orifice in the pipe so that the flow will approach the opening in straight and parallel lines. The condition of the piping, before and after the orifice, has a marked effect on the accuracy of measurement. Bends in the pipe, tees, obstructions—in fact, anything that will produce an uneven or a swirling motion—introduces an unknown factor in the accuracy of the measurement.

It is not always possible to obtain ideal conditions for the location of an orifice plate. It must be clearly understood, however, just what deviation from the standard may be allowed and what the effect will be on the accuracy of the measurement. In general, it may be said that the necessity of adhering to standard conditions depends upon the ratio of the orifice to the pipe area. When this ratio is small, a slight disturbance in the pipe seems to have a relatively small effect on the accuracy of the measurement. On this account it is often possible to place a small-ratio orifice under most unsatisfactory conditions of piping, where the medium or large-ratio orifice would not operate satisfactorily.

Long-radius bends and expansion loops may be considered the nearest approach to a straight length of pipe.

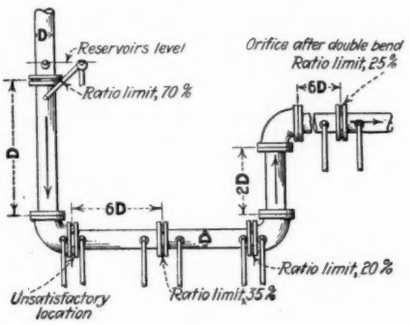


Fig. 2—Limitations on location of orifice plates imposed by elbows or bends

The effect of the centrifugal force is minimized by placing the pressure tap at right angles to the plane of the bend. In general, wherever the orifice is close to a given fitting, the pressure taps should be made as close to the flange as possible.

Limitations Imposed by Bends and Elbows

Fig. 2 is intended to demonstrate the limitations set by elbows or bends in a given line. It is always unsatisfactory to place an orifice after an elbow, while in front of the elbow low-ratio orifices may be used with satisfactory results. In all such cases the piping connections should be made as close to the flanges as possible. The suggested limits of the orifice ratio are shown on the figure.

Between the steam pipe and the meter body the piping forms the connecting link. The successful operation of the meter depends upon the attention given to this piping. The neglect of the operator in taking care of the connections cannot be overcome by any refinement of either the primary or the secondary device of the meter.

From the start great care should be exercised in drilling and tapping the pipe on both sides of the orifice plate. It is imperative that the connecting nipples do not project inside the pipe, because if they do eddies will be set up which will produce an aspirator effect that in turn will result in a fictitious pressure delivered to the meter body.

In measuring steam, the connecting piping is filled with water of condensation. It is necessary that the level of the water in the two pipes be maintained equal at all times. Should there be a variation in this water level, the pressure difference will be effected to the extent of this variation and, consequently, results will not be correct.

*From a paper read before National Association of Stationary Engineers, Grand Rapids, Mich., Sept. 11, 1924.

It is necessary that the connecting piping be graded so that any air that may be liberated by the water will work back and escape into the pipe, as, should there be a collection of air on one side, it is obvious that the pressure will be affected. In the measurement of air or gas the piping must be similarly graded so that all entrained moisture will come down toward the meter body.

Leaks Should Be Guarded Against

Above all, it is necessary to make certain that there is no leak between the differential medium and the meter body. There are cases where the static pressure in the line is measured in hundreds of pounds per square inch, while the differential is measured only in fractions of an inch of water. Any leak that may occur on either side of the instrument, while having little effect on the total pressure, will have a considerable effect on the differential pressure and, consequently, on the accuracy of the measuring device.

The size of the piping to be used for pressure connections to the meter body depends upon the distance to be carried or the length of piping required for the connections. In the case of the electrically operated flow meter the distance between the differential medium and the meter body need not be great, as the meter body may be placed close to the differential medium. In our experience ⅜-in. standard piping has proved satisfactory in 90 per cent of the flow-meter installations. In cases where the steam carries a large amount of impurities, a change to ½-in. standard pipe will prevent the possible stoppage of the piping. In such cases it is imperative to avoid any restrictions in the connections down to the meter body proper, where the piping should terminate with a set of blowoff valves through which the impurities can be blown out at regular intervals. In ordinary cases it is best to avoid the use of blowoff valves, as they form a source of trouble from careless opening or closing.

Each Meter Installation a Miniature Power Plant

From the viewpoint of electrical operation each meter installation forms a miniature power plant designed to drive the wheels of the reading instruments. The maximum consumption of the plant is limited to one ampere at 40 volts, which at this maximum, is equal to the consumption of one 40-watt lamp.

The meter is operated from any source of electric current available at the plant through a step-down transformer on the panel board. A small rotary converter may be used in plants where only direct current is available. The reason for employing alternating current is because it can be stepped down easily to the standard voltage for which the resistances are designed.

The electric wiring forms the connecting link between the meter body and the reading instruments, the same as the connecting piping forms the link between the differential medium and the meter body. The analogy between the two brings out the fact that the electric link will eliminate a good deal of the trouble inherent to the care of the first link, simply because it makes it possible to bring the meter body close to the differential medium, thus eliminating excessive length of piping. As far as the care of the electric wiring is concerned, there never has been any difficulty, even in cases where the distance was over a mile in length and the wiring passed through many buildings on the line.

The instruments proper are four in number: The curve-drawing instrument or recorder, the totalizing instrument or integrator, the panel board indicator and the boiler indicator. These instruments, while especially designed for the registration of flow, are similar to the construction of the corresponding electric meters—the ammeter and the watt-hour meter—and require little attention for continuous service in the power plant.

The Freeman Integrator

Prior to 1920 the totalizing instrument or integrator was a regular watt-hour meter and accordingly the registration of the instrument represented the actual product of the volts times the amperes or the units of electric energy passed through the circuit. From the relation expressed by Ohm's law, an increase in the voltage would also increase the current and, accordingly, would increase the reading of the integrator in proportion to the square of the increased voltage. This was the great stumbling block left to overcome in order to make the meter applicable for the power plant. Very few plants had reliable voltage regulation in the system, and therefore the accuracy of the meter depended upon the constancy with which the voltage was maintained at the switchboard. After the elimination of the excessive service requirements by the addition of seal chambers to the meter body, attention was turned to the elimination of this defect in the accuracy of the meter. Prof. E. H. Freeman, of the Armour Institute of Technology, was called upon for assistance and designed the Freeman integrator which now replaces the watt-hour meter. With the introduction of the Freeman integrator and the elimination of the effect of a change in voltage, the electrically operated flow meter became a most accurate instrument for integrating the flow of fluids in pipes.

Progress with Merit System by Michigan N.A.S.E.

Interest in the N.A.S.E. just now is centered on the State of Michigan, where a novel merit system of rating its members was put in motion about a year ago, largely through the efforts of Garrett Burgess, the present National Vice-President. While the actual work has been in full swing only for a few months, considerable enthusiasm has been evinced and great results are predicted for the new system.

The scheme, in brief, is for the State Association to examine its members and, on the basis of such examinations, issue them certificates of merit, these certificates to state the branch or branches of engineering in which the members are competent. In connection with this, the State Association establishes a system of lessons preparatory to the examination.

While it might seem, at first sight, that the certificate of merit simply duplicates the function of the engineer's license, this is said to be by no means the case. It is pointed out that the engineers' license laws are designed mainly to safeguard the community against accidents, that they are based largely on the practice of twenty years ago, that they specify only a minimum requirement (that is a "passable" engineer) and that, in some cases at least, they are subject to political misuse.

The advocates of the Michigan system claim that the average engineer studies diligently until he obtains a license and then loses further interest. He needs something more to stir his ambition to study. The certificate of merit, signed by the officers of his own organization and recognized by chambers of commerce, and manufacturers associations gives the ambitious a definite goal and insures the satisfactory completion of the course by most of the better engineers in the organization.

The Courses Offered

At the present time the Michigan Association offers courses leading to certificates of merit in the following subjects: Steam engineering, electrical engineering, refrigeration engineering, combustion engineering and supervising engineering, the last-named including all of the foregoing plus power-plant costs. The educational department consists of the state president, state vice-president and six members, three chosen by the president and three by the vice-president. The state is divided into two districts, for each of which the state president appoints a chief examiner and associate examiner for a term of from one to five years. All members of the committee serve without remuneration, except that expenses are paid.

The educational department supplies the subordinate associations with the necessary educational data for carrying on the courses, papers being forwarded to the department for correction and grading. After passing a given course to the satisfaction of the educational department, an applicant is recommended for examination in that branch. He is examined by a special committee of at least five members.

An applicant who has had sufficient experience and is known to be a qualified *practical* engineer, may appear before the examining committee for a verbal examination only and, upon answering all questions satisfactorily, may be issued a certificate of merit marked "Practical." It is estimated that the average engineer, to complete the course in all its branches, will have to devote from five to six years to study at a net cost of six dollars.

The Pacific Gas and Electric Co. has applied for a license covering an existing diversion dam and canal, a portion of which is on public lands. These works are a part of the lime saddle-coal canyon power project on the west branch of the North Fork of Feather River, near Oroville in Butte County, California. The company requests that this license be granted as a minor part of the major project.

Recent Publications

The Diesel-Electric Locomotive (Diesel Elektrische Lokomotive). By Prof. G. Lomonossoff. Published by the VDI—Verlag, Berlin. Paper covers; 9x12 in.; 186 pages; 269 illustrations. Price, $5.

While much research work has been done on the subject of the oil-engine locomotive, heretofore no attempt has been made to collect this material in a form available for engineers. Professor Lomonossoff takes up the several different types of oil-engine locomotives, including several in which gasoline engines provide the motive power. While a volume of appeal to but a limited number of engineers, it has the merit of covering certain phases of the subject heretofore neglected.

Elements of Electrical Engineering. By Arthur L. Cook, Supervisor, Course of Electrical Engineering, Pratt Institute. Published by John Wiley & Sons, Inc., New York and London, 1924. Cloth; 9x6 in.; 568 pages. Price, $4.

Fundamentals of electrical engineering and their application in practice are treated of in this book. It is intended as text for students taking short courses in electrical engineering and for non-electrical students in colleges. The book has been prepared for students who have a knowledge of the principles of electricity and magnetism such as might be given in a course in physics. The work is divided into four parts: Electric and magnetic circuits; direct-current machinery; alternating current; and alternating-current machinery. No attempt has been made to describe all types of electrical machinery. The subjects discussed are those that the author's engineering experience has shown are most commonly needed by the average engineer and those that best serve to illustrate the fundamental laws.

In the section on electric and magnetic circuits the simple fundamentals of electricity and magnetism are treated of. Part II, dealing with direct-current machinery, covers generators and motors of the conventional types and machines with commutating poles and compensating windings, arc welding, storage batteries and direct-current power distribution. In Part III the fundamentals of alternating current and alternating-current circuits are dealt with and in Part IV transformers, generators, motors, rotary converters, switching and control equipment, motor applications and illumination are discussed. Excepting in Parts I and II mathematics has not been used to any great extent. An effort has been made to bring out the physical significance of a result rather than the mathematical derivation of a formula. An attempt has been made to reduce the use of formulas to a minimum so as to encourage the student to derive his results from fundamental laws. For this reason, although the book has been written for use of students attending colleges, it has much to recommend it to those who are endeavoring to obtain a better understanding of electricity and magnetism and electrical machinery in their spare time and have not the opportunity to attend school.

Industrial Electricity, Part 1. By Chester L. Dawes, Assistant Professor of Electrical Engineering, Harvard University. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, 1924. Cloth; 6x8 in., 267 illustrations. Price, $2.25.

On account of the rapid increase in the application of industrial electricity the courses of educational training in this line have also increased rapidly in schools not of collegiate grade. This book, which is one of a series of texts outlined by a committee of well-known electrical engineers, has been written to meet the needs of courses in elementary industrial electricity. The work has been confined to electrical machines and their fundamental principles. No attempt has been made to cover such subjects as electric lighting or systems of communication. Seven chapters deal with the fundamentals of electricity, magnetism and electric circuits, two chapters treat of primary and secondary batteries, electrical instruments and measurements are covered in one chapter of 40 pages, and the remainder of the work, 100 pages, is devoted to direct-current generators and motors. A large number of questions and problems are given to assist students and instructors in interpreting the text of the various chapters and applying the principles defined. Although the book is written primarily for use in classrooms, where the student is under the guidance of an instructor, those that may not be so fortunate as to have this opportunity will find much in this volume to assist them to a better understanding of direct-current machinery.

"Custodis Chimneys." Prepared and published by Alphons Custodis Chimney Construction Co., 95 Nassau St., New York City. Paper; 8½x11 in., 92 pages; numerous photographs, diagrams and tables. Furnished free on request.

The title "Custodis Chimneys" does not indicate the scope of this book which is largely given over to the technical fundamentals, presented in a form suited to the needs of the trained engineer and architect. This technical section includes explanations of the theoretical draft formulas, discussion of empirical chimney formulas with tables, methods of computing draft losses, sample computations for chimney height and diameter, structural design of chimneys to resist wind, wet weather and acid gases, stability of foundations, map of the United States showing wind velocities in all regions, wind-pressure computations, strength of brick work, weight of masonry, temperature stresses, foundation design with drawings of standard details, lightning protection and standard specifications for chimneys. The first part of the book is adorned by many interesting photographs of chimneys, including the largest in the world, that at Anaconda, Mont., which has a height of 585 ft. and a 60-ft. internal diameter at the top. This book would be a valuable addition to any engineer's library.

"Smoke Abatement: A Study of the Police Power as Embodied in the Laws, Ordinances and Court Decisions," by Lucius H. Cannon. Librarian, Municipal Reference Library, St. Louis, Mo. Published by the St. Louis Public Library. Paper; 6¾x9¼. Price, 50 cents.

This comprehensive book on the smoke problem is especially timely and should be of real value to state and municipal authorities in dealing with the legislation on this subject. The smoke problem is taken up from every angle, but especially interesting and useful are the chapters on "History of Smoke Abatement in American Cities," which has the legal slant, "Bibliography of Smoke Abatement," and the well-arranged index.

Fünfundzwanzig Jahre Zeppelin Luftschiffbau (Twenty-five years of Zeppelin Air Ship Building) by Dr. Ing. L. Dürr, direktor, Friedrichshafen. Published by V. D. I. Verlag G. M. B. H.,, Berlin SW 19 Beuthstn 7, Germany. 83 pages with 186 text illustrations. Printed in German. Paper; 9x12 in. Price 8 marks. This book is a history of the Zeppelin or airship progress and contains information in regard to development of designs of parts and materials as well as types.

Bibliography on Riveted Joints. Prepared by Dr. A. H. Stang, of the Bureau of Standards, aided by the Special Research Committee on Riveted Joints, A.S.M.E. Published by the American Society of Mechanical Engineers, 29 West 39th St., New York City, from which society it can be had for 75 cents by members and for 85 cents by non-members.

The British Engineers' Association Official Directory of Members and their Manufactures, 1924, is published by the Society, 32 Victoria St., Westminster, London, S. W. 1, and contains, besides an alphabetical list of members, announcements of their manufactures and a list of the members exhibiting at the British Empire Exhibition, held at Wembley during the summer.

(A.S.M.E.) Transactions Index, Vol. 1-45, 1880-1923. Published by the American Society of Mechanical Engineers, 29 West 39th St., New York City. Cloth, 6¼x9 in.; 222 pages. Price, $3.

The 1924 Year Book of the Society of Naval Architects and Marine Engineers beside the regular list of members, etc., gives an Index of Titles of Papers in its volumes 1-31.

Practical Experience Stressed for Engineering Graduates

The board of trustees, University of Pennsylvania, has voted to adopt revised and more rigid requirements from graduate candidates for the degrees of chemical engineer, electrical engineer, civil engineer or mechanical engineer, from the Towne Scientific School at the institution. Heretofore those seeking such degrees have been required to get 3 years practical experience and to write a thesis on some technical phase of their particular branch of engineering. In the future candidates must be in active practice for at least 7 years and in charge of important work in their field for 3 or more years.

30-Day Test on Worthington Double-Acting Diesel

The salient features of the double-acting two-stroke-cycle Diesel engine built by the Worthington Pump & Machinery Corp., at its Buffalo works, were discussed in *Power*, Sept. 16. The builder undertook to prove performance of the single-cylinder unit, in which are embodied all the characteristics governing the operation of a multi-cylinder engine by a thirty-day non-stop run at full load and at rated speed. It will be recognized that such a test, rigorously and literally carried out, was of unusual severity; not because of any inherent basic difficulties, but because of the possibility of minor failures, or need of adjustment in comparatively insignificant and non-essential details, any one of which might cause interruption.

In order to avoid any question as to complete authenticity of performance, the test was run under continuous observance of Shipping Board representatives. The complete and absolutely uninterrupted continuity of this run indicates that the engine possesses those characteristics necessary in an engine of this size.

The run began at 10:05 p.m., Sept. 25, and closed at 10:05 p.m., Oct. 25. The engine was operated at a speed of 90 r.p.m. with an average load of about 62 brakes m.e.p., which is substantially identical with the commercial rating of the engine. The load was absorbed by a water brake, and a continuous log has been kept under the observation of Shipping Board representatives. Essential observations were taken at two-hour intervals, indicator diagrams were taken on each eight-hour shift, and tests of fuel consumption and lubricating oil were made weekly. Examination of the log shows an astonishing uniformity and consistency of performance. The engine has been notably cool in bearings, piston rod and cylinders and the exhaust clear and clean.

The following results, were attested by Oscar Olson, representing the Shipping Board, and R. C. Mathewson, representing the builder:

Beginning of test, Sept. 25, 10:05 p.m.	
Termination of test, Oct. 25, 10:05 p.m.	
Duration of test hours	720
Total number of revolutions during test	3,879,921
Average, r.p.m.	89.8
Average brake load, lb.	2,400
Length of brake arm, ft.	15
Average brake horsepower	615
Average indicated m.e.p., top cylinder, lb.	81
Average indicated m.e.p., bottom end, lb.	77
Average indicated horsepower	778
Fuel oil consumption average of four 2-hour tests per b.hp. hour, lb.	0.428
Gravity of fuel used, deg. Bé.	28 to 32
Fuel oil consumption per i.hp. per hour, lb.	0.339
Mechanical efficiency measured during the four tests, per cent	79.5
Lubricating oil consumed in the cylinder and piston-rod stuffing box per 24 hours, gal.	4.03
Average exhaust temperature, deg. F.	510

The engine ran at a steady speed, without a single stop, during the entire period of the test. The exhaust investigated close to the outlet from the cylinder, was at all times invisible.

Readings of temperatures of cooling water, exhaust gases, cylinder liners, etc., and of pressures of scavenging air, injection air, oil pressure, etc., were remarkably steady during the entire period of the test. The running of the engine was as smooth as that of a steam engine, and was marked by an entire absence of harmful vibrations.

Franklin Institute Presents Medals

The distinguished physiologist, Dr. Archibald Vivian Hill, Jodrell professor of physiology in University College, London, delivered an address, Oct. 15, before the Franklin Institute on how man's muscular machine works, which deal with the delicate measurements of force, heat and electrical change in muscles.

Before the lecture three medals were awarded by the Franklin Institute, for inventive achievement. They were:

A. Louis Edward Levy Medal to Dr. Harvey Fletcher, research physicist of the American Bell Telephone & Telegraph Co. and the Western Electric Co., for his investigations in the field of physical measurements of hearing; an Edward Longstreth Medal was presented to Thomas C. McBride for his locomotive feed-water heater, which uses exhaust steam to heat feed water before it is supplied to the locomotive; an Edward Longstreth Medal was bestowed on Milton Roy Sheen for his development of the Sheen Tunneler, a machine that digs conduits as much as thirteen feet in diameter without disturbing the surface of the ground—driving the tunnel, compacting the earth at the sides and top of the tunnel without leaving any cavities and installing the concrete lining. His method avoids all danger of cave-ins and saves, he asserts, half the cost of old-time methods of digging such conduits.

Russell Sage Foundation Makes Employment Study

The Russell Sage Foundation has recently finished a report on its five-year study of employment methods, needs and agencies in the United States and Canada. Practically every known means for bringing work and worker together was studied. The "want ad" pages of newspapers, the fee-charging labor agencies, the free public employment office, the labor union's method of securing work for its members, the fraternal order's activities in this field, the practice of applying for work at the factory gate or the office door were all investigated. Of the state administrations it has this to say:

"Whatever the shortcomings of state administration, the fact remains that 26 states have established and are now operating public employment offices. While the development of efficient and scientific methods may have been unduly delayed, there has been much progress."

Recommendations summarized are:

"That the Federal government encourage and assist the states to maintain adequate systems of public employment offices and to co-ordinate these into an effective nation-wide service.

"That the states administer and support their own employment offices, subject to the terms of agreement with the federal government; and that the local governments participate in the management of the offices in their community through representation on their local employment committee.

"That in order to establish the non-partisan character of the service, the functions to be performed by the federal government be administered by a board appointed by and directly responsible to the President.

"That this board consist of the Secretary of Labor, the Secretary of Commerce and the Secretary of Agriculture.

"That a National Council and local employment committees representing employers, workers, and possibly other allied interests be established as an additional aid in securing neutrality of administration as well as a reputation for such.

"That the procedure of the service in respect to demands for workers by employers in whose establishments a strike or lockout is in progress or is pending, shall be such as to guarantee the neutrality of the service."

Secretary Henry C. Wallace Dies on Oct. 25

The water power act lost one of its most ardent supporters in the death of Henry C. Wallace, the Secretary of Agriculture. As a member of the Federal Power Commission, Secretary Wallace consistently favored the acceptance by the Commission of the responsibilities vested in it. He was very definitely opposed to the action of the Commission in its failure to act on the Girand license and the indefinite postponement of action on Colorado River projects.

Changes Made in Stave Lake Power Plant Plans

The British Columbia Electric Railway Co. will make expenditures this year of approximately $5,000,000 on power-plant extensions and equipment. At the Stave Falls plant a fifth generator will be installed and the four existing generators will be rewound, to increase the output from 36,000 to 55,000 kw. due to the increased head of water since the dam was raised. This makes the remodeled plant's equipment to consist of four units of 10,500 kva. and one unit of 13,125 kva., or a total of 55,125 kva. The cost will be about $1,000,000 and is expected to be completed by November, 1924.

On the Alouette Lake project, which is adjacent to Stave Lake, $760,000 will be spent in 1924 and $1,385,000 to complete the development in 1925. The power plant, which will be situated at the mouth of the tunnel between Alouette Lake and Stave Lake, will generate 9,000 kilowatts.

United States Petroleum Exports Large

That petroleum and petroleum products make the second largest group in America's export trade, was brought out in a bulletin on the country's world trade, just published by the Foreign Commerce Department of the Chamber of Commerce of the United States. Gas and fuel oil exports, shipped largely to England, Panama, Canada, Chile, Mexico and Japan, increased 24 per cent in volume and 35 per cent in value, the exports for the January-June, 1924, period totaling 2,700,000 tons at $22,999,000, as compared with 2,184,000 tons at $17,094,000 the year before.

Exports of lubricating oil, our eighth export, amounted to 789,600 tons, valued at $48,518,000, for the first six months of this year, a 10 per cent gain in volume and a 17 per cent increase in value over the exports of the first half of 1923—716,200 tons, with a value of $41,314,000. European countries were the chief purchasers.

We also exported 24,967 tons of lubricating greases, value $2,565,000, this year, an increase in quantity of 38 per cent above the 18,044 tons shipped during January-June, 1923.

Potomac Power Co. Opens Steam Plant Addition

More than 200 of Washington's prominent residents were the guests of the Potomac Electric Power Co. on the occasion of the opening of a new addition to its large steam plant. The growing load in the District of Columbia, and near-by territory made necessary this addition, which just has been completed by Stone & Webster. It consists of an extension of the turbine room and electrical gallery, in which has been installed a 20,000-kw. General Electric turbo-generator with the necessary condensers, circulating pumps, exciters and switch gear. A part of the improvement is a new boiler house containing three Babcock and Wilcox boilers, with underfeed stokers and the necessary coal- and ash-handling equipment. These additional facilities have been installed at a cost of $1,800,000.

The Potomac company's plant now is equipped with 35 boilers capable of evaporating 2,500,000 lb. of water per hour. The station now has nine turbo-generators with a total capacity of 118,000 kw. The company operates 23 substations.

This is the fourth addition to the Benning plant of the company, which was built originally in 1906, with two 5,000-kw. units. The company's load is growing at a rate which indicates that the next 20,000-kw. unit must be ready for operation during 1927. The annual consumption of coal at the plant now is at the rate of 300,000 tons.

STOKERS SOLD DURING 1923, JAN.-SEPT. 1924

Year and Month	Establishments Reporting (Number)	Stokers Sold — Number	Stokers Sold — Serving Sq.Ft. of Heating Surface	Installed Under — Fire-Tube Boilers — Number	Fire-Tube Boilers — Sq.Ft. of Heating Surface	Water-Tube Boilers — Number	Water-Tube Boilers — Sq.Ft. of Heating Surface
1924							
January	15	91	664,920	7	10,440	84	654,480
February	15	110	621,130	11	15,250	99	605,880
March	15	89	345,970	12	16,250	77	329,720
April	15	89	479,390	15	19,700	74	459,690
May	15	64	344,470	3	5,500	61	338,970
June	15	102	355,490	19	27,240	83	328,250
July	15	115	377,590	14	16,600	101	360,990
August	13	94	419,310	17	24,860	77	394,450
September	13	73	259,880	27	66,460	46	193,420
1923							
January	15	145	832,700	29	34,000	115	798,700
February	15	129	666,190	9	11,720	120	654,470
March	15	120	689,550	9	12,590	111	676,960
April	15	167	853,390	14	20,000	153	833,390
May	15	194	1,005,130	14	19,150	180	985,980
June	15	135	597,190	6	8,040	129	589,150
July	15	129	525,180	21	34,540	108	490,640
August	15	135	716,930	18	26,240	117	690,690
September	15	99	604,860	16	27,540	83	577,320
October	15	88	325,760	14	23,300	74	302,460
November	15	50	162,410	10	13,000	40	149,410
December	15	73	325,170	17	28,200	56	296,970
Total, 1923	..	1,464	7,304,460	177	258,320	1,287	7,046,140

Department of Commerce.

Gorge Creek Plant Put in Service by City of Seattle

On Sept. 27 the Gorge Creek plant comprising the first unit of Seattle's municipal hydro-electric project on the Skagit River was officially put in service after several weeks of testing and preliminary tryout.

The present installation consists of two 37,500-hp. S. M. Smith vertical reaction turbines which for the present are operating at about two-thirds capacity under a head of 285 ft. pending the construction of a concrete diversion dam which is to increase the head by about 100 ft.

As the Skagit project stands today, including construction railroad, Newhalem plant, north substation, Gorge plant, and the 100-mile, 165,000-volt transmission line, the total cost is stated to be $12,680,000, including interest during the construction period.

Society Affairs

The Detroit Engineering Society will have as the attraction for its Nov. 14 meeting, a paper by A. H. Frost, of the Vacuum Oil Co., on "Correct Lubrication."

The Metropolitan Section of the A.S.M.E. will hear Webster Tallmadge on "Present Day Problems in Steam Piping," at its Nov. 12 meeting, which will be held at the Engineering Societies Bldg., New York City.

The Buffalo Section of the A.S.M.E. will hold a joint session with the E.S. of B., and E.I.E. on Nov. 7. A paper on "Fatigue of Metals," by Professor Moore, of the University of Illinois, will be the attraction.

The Western Society of Engineers will have a "Symposium on Bearings" at its Nov. 10 meeting, which will be held in the Monadnock Bldg., Chicago, Ill. Representatives from the G. E. Co., Hyatt Co. and the Storm Ball Bearing Co. will be the speakers.

The Knoxville Section of the A.S.M.E. will discuss "The Effect of Straightening a River Channel Upon Flood Effects Below the Section Changed," at its Nov. 17 meeting, which will be held in the Civics Bldg. The discussion will be led by Prof. J. A. Switzer, of the University of Tennessee.

Personal Mention

Broido, B. N., who has been doing special consulting work for the Superheater Co., of New York City and Chicago, has recently been appointed chief engineer of the industrial department of the company.

John B. Challies, who has been director of water power since 1919 in the Canadian Department of the Interior, has resigned to accept an executive position with the Shawinigan Water & Power Co., of Montreal.

Frederick A. Smith, having severed his connection with the Bureau of Engineering, Department of Public Works, Chicago, announces the opening of an

office in Chicago at 208 North Wells St., Room 411, where he will devote his time to consultation on engineering matters dealing especially with hydraulics and municipal and railway construction problems. He is also prepared to give instruction in technical arithmetic, mathematics and in the solution of engineering problems.

Business Notes

The B. F. Sturtevant Co., Hyde Park, Mass., announces the appointment of Raymond S. Shaw, formerly manager of the New England office at Boston, as general sales manager of the company.

The Edwin Burhorn Co., engineers, contractors and manufacturers, 25 West Broadway, N. Y., recently opened an office at room 805 Mayo Bldg., Tulsa, Okla. Joseph S. Arbuckle is district manager in charge.

The S. Morgan Smith-Inglis Co., of Toronto, Canada, is a new corporation which is the result of the combination of the engineering facilities and experience of the S. Morgan Smith Co., York, Pa., and the manufacturing plant of John Inglis Co. of Toronto, a plant adapted to the production of water turbines. Future installations of the S. Morgan Smith Co. in Canada will be with turbines built on Canadian soil by the new Toronto company.

The Fuller-Lehigh Co., 50 Church St., New York City, has just announced that it entered last July into an agreement with the Babock & Wilcox, Ltd., of London, England, to operate under the Fuller-Lehigh patents whereby everything in connection with its pulverized-coal business will be handled in the various countries throughout the world by the English company, with the exception of the United States, its dependencies, Canada and Mexico. Inasmuch as the Babock & Wilcox, Ltd., has modern manufacturing plants in many parts of the world, it enables these countries to save the duty and freight on the material and makes it practical to install the necessary equipment to use pulverized coal much more extensively. The Babcock & Wilcox, Ltd., has taken over a large number of the Fuller organization who have specialized in pulverized coal.

Trade Catalogs

Regulators, Feed Water—Northern Equipment Co., Erie, Pa. Catalog "A," "Modern Methods of Boiler Feed Water Regulation," shows the Copes system of boiler feed-water control. It is fully illustrated with photos, drawings and curves, and can be obtained upon request.

Speed Reducers—Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill. Catalog No. 25 describes the IXL spur-gear speed reducer and the IXL worm-gear speed reducer, which are made by this company. Price lists, tables of dimensions and weights and good illustrations make up an attractive 79-page book, which may be obtained upon request.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution Washington, D. C. Meeting at Washington Dec. 29-Jan. 3, 1925.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Annual meeting at Hotel Schenley, Pittsburgh, Pa., Dec. 3-6.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at New York City, Feb. 9-13.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 16-19.

American Society of Heating and Ventilating Engineers. F. C. Houghten, 33 West 29th St., New York City. Annual meeting at Boston, Jan. 28-30.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Canadian Association of Stationary Engineers and Power Exposition. Miss Violet Pearce, 139 Essex Ave., Toronto, Ont. Convention at Windsor, Ont., June 23-25, 1925.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Eighteenth annual meeting at Hotel Chelsea, Atlantic City, N. J., Nov. 12-14.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Que. Annual meeting at Montreal, Que., Jan. 27-29.

Exposition of Inventions. E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Building, 29 West 39th St., New York City, Dec. 8-13.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Des Moines, Iowa, Jan. 27-30, 1925.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14. Exhibits at the Isaac Delgado High School.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Marine Engineers Beneficial Association, Geo. A. Grubb, 313 Machinists Building, Washington, D. C. Convention at Hotel Franklin Square, Washington, D. C., Jan. 19.

Society of Automotive Engineers. C. F. Clarkson, 29 West 39th St., New York City. Annual meeting at Detroit, Mich., Jan. 20-23.

Society of Naval Architects and Marine Engineers. Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at 29 West 39th St., New York City, Nov. 13-14.

Western Association of Electrical Inspectors. G. M. Miller, 1304 South 7th St., Louisville, Ky. Annual convention at the Brown Hotel, Louisville, Ky., Jan. 27-28.

Recorder, Automatic and Draft—The Jos. W. Hays Corp., Michigan City, Ind." "Operating Instructions" is a booklet that tells about the proper way of installing the automatic CO_2 and draft recorder, and gives the proper location of sampling pipe as well as other instructions for the operation of these instruments.

Circuit Breakers—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. "Carbon Circuit Breakers, Type CL, for Industrial Applications," circular C-1705 describes breakers designed for use on 250-volt industrial systems, but which may be used on 600-volt lines if barrier are placed between poles. The description is supplemented with cuts and drawings showing the various types and applications of these breakers.

Flow Meters, Electrically Operated—General Electric Co., Schenectady, N. Y. Instruction Book No. 86518 for installing and operating G-E electrically operated flow meters for steam, water and air flow, types FE to FE14 inclusive, 25 to 60 cycles, 110 to 125 volts gives specific instructions, with clear drawings and photos, of the different parts of the meter and their action. Bulletin No. 46517 also describes these electrically operated flow meters.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 20, 1924	Oct. 27, 1924
Pool 1	New York	$3.00	$3.00
Smokeless	Columbus	2.50	2.50
Clearfield	Boston	2.50	2.25
Somerset	Boston	2.35	2.40
Kanawha	Columbus	1.65	1.65
Hocking	Columbus	1.65	1.65
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.20
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.90	1.80
S. E. Ky.	Louisville	1.75	1.75
Big Seam	Birmingham	1.75	1.75

FUEL OIL

New York—Oct. 31, light oil, tank-car lots; 28@34 deg. Baumé, 4¾c. per gal.; 36@40 deg. 5c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Oct. 28, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75 per bbl.; 28@30 deg., $1.80 per bbl.; 30@32 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4.8c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Oct. 29, f.o.b. local refinery; 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.

Dallas—Oct. 28, f.o.b. local refinery, 26@30 deg., $1.15 per bbl.

Philadelphia—Oct. 30, 28@30 deg., $2.10@$2.15 per bbl.; 18@22 deg., $1.87½@$1.93¾; 13@16 deg., $1.75@$1.81½ per bbl.

Boston—Oct. 27, tank-car lots, f.o.b.; heavy oil, 12@14 deg. Baumé, 4.2c. per gal.; light oil, 28@32 deg. Baumé, 5¼c. per gal.

Cincinnati—Oct. 28, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5½c. per gal.

Chicago—Sept. 29, 20@22 deg., 5½c. per gal.; 24@26 deg., 6c. per gal.; 28@30 deg., 6c. per gal.

New Plant Construction

Ark., Little Rock—Local Syndicate, c/o J. F. Boyle et al., Boyle Bldg., awarded the contract for the construction of a 10 story hotel at Louisiana and 7th Sts., to A. D. Gates Construction Co., Chemical Bldg., St. Louis, Mo., estimated cost $1,000,000.

Calif., Los Angeles—Sun Realty Co., 1414 South Los Angeles St., is having plans prepared for the construction of an 11 story, store and loft building on 7th St. Curlett & Beelman, Union Bank Bldg., are architects.

Calif., Whittier—The City, P. Gilmore, Clk., will receive bids until Nov. 10 for one horizontal centrifugal pump with 220 v., 3 phase induction motor.

Colo., Denver—Board of Water Comr., 1509 Cleveland Place, will receive bids until Nov. 20 for pumping equipment, including one 15 m.g.d. steam turbine driven centrifugal pump with condenser, one 10 m.g.d. motor driven centrifugal pump with starter complete, etc.

Fla., Cocoanut Grove — The Board of Aldermen and H. De B. Justison, Mayor, will receive bids until Nov. 24 for the construction of a waterworks system, including power and pumping station, electric generating machinery, motor driven centrifugal pumps and compressors, etc. Main Engineering Co., Daytona, are engineers.

Fla., Deland—The City plans an election on Nov. 28 to vote $300,000 bonds for the construction of a power plant.

Ill., Garden Prairie—Gifford Milk Products Co., 413 North State St., Chicago, having preliminary plans prepared for the construction of a boiler house. Cahill & Douglas, 217 West Water St., Milwaukee, are engineers.

Kan., Iola—The City, O. W. Holmes, Clk., will receive bids until Oct. 29 for a disposal plant, including two 1,000 g.p.m. and one 500 g.p.m. motor driven centrifugal pumps, etc., estimated cost $115,000. A. C. Moore, Joplin, Mo., is engineer.

Kan., Wichita—U. S. Treasury Dept., Supervising. Architect's Office, Washington, D. C., will receive bids until Nov. 21 for the installation of one full magnet electric freight elevator complete, for the U. S. Post Office and Court House here. J. A. Wetmore is acting supervising architect.

Mass., Winchester—Winchester Hospital, Highland Ave., plans the construction of a power house and laundry, estimated cost $40,000. Kendall Taylor & Co., 142 Berkley St., Boston, are architects.

Mo., Appleton City—The City is having preliminary plans prepared for the construction of a water works system, including pumping plant, reservoir, etc., estimated cost $100,000. Burns & McDonnell, 402 Interstate Bl., Kansas City, are engineers.

Mo., Kansas City — Clark Estate Co., 3317 Broadway, awarded the contract for the construction of a professional office building, to Reyburn Engineering and Construction Co., 609 Waldhem Bldg. Estimated cost $750,000. Steam heating system will be installed.

Mo., St. Louis—Shubert Interests, c/o Shubert, Jefferson Theatre, 12th and Locust Blvd., is having preliminary plans prepared for the construction of a theatre and hotel to contain 800 rooms or more. Private plans.

Mo., St. Louis—Skouras Enterprises, c/o Grand Central Bldg., Grand Blvd. at St. Lucas Ave., is having preliminary plans prepared for the construction of a theatre and office building, estimated cost $1,000,000. Private plans.

Mo., St. Louis—Wood & Lane Co., Syndicate Trust Bldg., is in the market for a uniflow engine unit consisting of a 75 to 100 kw. generator direct connected to Ames or Skinner type uniflow engine.

Nev., Fallon—The City voted a $50,000 bond issue for a municipal lighting plant.

N. J., Newark—L. S. Plaut & Co., Pres. & Treas. of S. S. Kresge Co., 576 Fulton St., Brooklyn, N. Y., awarded the contract for the construction of a 9 story building at Broad, Cedar and Halsey Sts., to Starrett Bros., Inc., 101 Park Ave., New York, estimated cost $5,000,000. Steam heating system will be installed.

N. Y., Larchmont—Village Trustees, C. H. Reisig, Pres., will receive bids until Nov. 20 at office of Managing Clk., Municipal Bdg., for sewerage system improvements, including 2 motor driven vertical centrifugal sewage pumps capacity 500,000 g.p.d., 1 gasoline driven horizontal centrifugal sewage pump 1,000,000 g.p.d., two 750 g.p.m. motor driven vertical centrifugal sludge pumps, 8 sewage ejectors with 8 motor driven air compressors, 4 air driven direct acting sump pumps, 1 motor driven blower capacity, 7,600 cu.ft. of free air per min., 2 motor driven blowers capacity 50 cu.ft. of free air per min., and chlorinating apparatus.

N. Y., New York—W. & J. Manger, 783 5th Ave., awarded the contract for the construction of a 20 story hotel at 7th Ave. and 51st St., to Bing & Bing, 119 West 40th St., estimated cost $5,500,000. Steam heating system will be installed.

N. Y., New York—St. Vincent's Hospital, 12th St. and 7th Ave., is having plans prepared for the construction of a 13 story nurse's home including steam heating system, estimated cost $750,000. I. E. Ditmars, 111 5th Ave., is architect.

O., Ashtabula—Aetna Rubber Co., plans the construction of a power house, including three 150 hp. boilers. C. J. Dunne is general manager.

Okla., McAlester—Scottish Rite Masons, plans the construction of a 2 and 4 story hospital, including refrigeration plant and separate heating plant, estimated cost $200,000. W. T. Schmitt, 1634 West 10th St., Oklahoma City, is architect.

Pa., Easton—Thomas, Martin & Kirkpatrick, Otis Bldg., Phila., Archts., will receive bids until Nov. 10 for the construction of a 7 story hotel at Hampton and Green Sts., for the Hotel Easton Corporation, Northampton Bk., estimated cost $1,000,000.

Pa., Harrisburg—Polyclinic Hospital, H. Gross, Front and Harris Sts., awarded the contract for the construction of a 3 and 4 story hospital on 3rd Ave. and 4th St., to W. E. Bushey, Lemoyne, estimated cost, $700,000.

Pa., Philadelphia—Lehigh Silk Hosiery Mills, Inc., awarded the contract for the construction of manufacturing buildings and boiler house on Ontario St., to Turner Construction Co., 1713 Sansom St.

Pa., Philadelphia—Pelham Terrace Apts., E. Hutchinson, Jr., Pres., awarded the contract for the construction of a 9 story apartment house at Emlen and Carpenter Sts., to Boyle Robertson Construction Co., Evans Bldg., Washington, D. C.

Tenn., Nashville—Cumberland Improvement Co. plans the construction of an 18 story office building at 3rd and Church Sts., estimated cost $1,300,000.

Tenn., Watertown — The City had preliminary plans prepared for the construction of a new water works system, including well, pump, tank, tower, etc., estimated cost $127,000. Engineer not selected.

Tex., Crowell — R. Porter, Blackwell, Okla., is having plans prepared for the construction of an electric power and ice plant, estimated cost $100,000. Owner is in the market for machinery for 40 ton capacity ice plant and dynamos, motors, etc., for power plant.

Tex., El Paso — R. Orndorff is having plans prepared for the construction of a 10 story, 110 x 170 ft. hotel, including 2 elevators, electric installation, steam heating plant, etc., estimated cost $750,000. Trost and Trost, Republic Bldg., are architects and engineers.

Tex., Galveston—C. K. Jorgenson Co., plans the construction of a 11 story hotel, estimated cost $800,000. W. S. Murdoch, 6605 Avenue N., Houston, is architect.

Tex., Haskell—W. T. U. Co. plans the construction of a 30 ton ice plant, including machinery, estimated cost $25,000. Nichol & Campbell, Abilene, are engineers.

Tex., Houston—South End Ice Co., c/o T. B. Hubbart Co., Bankers Mortgage Bldg., will soon receive bids for the construction of an ice plant on West Webster St., estimated cost $65,000.

Tex., Littlefield—R. E. McCaskill, Electra, is having plans prepared for the construction of an electric light and power plant system, estimated cost $60,000.

Tex., McAllen—Carroll College, Board of Trustees, J. M. Carroll, Pres., will receive bids until Dec. 1 for the construction of a 3 story college building and a 20 x 40 ft. power house, estimated cost $300,000. H. Smith, Commerce National Bank, San Antonio, is architect.

Tex., Port Arthur—J. R. Adams, will soon award the general contract for the construction of a 7 story store and office building, estimated cost $600,000. H. C. Moner, Beaumont, is architect.

Tex., Port Arthur—The city is having plans prepared for the construction of a new water works system, including pumping equipment, estimated cost $48,000. Terrell Bartlett Engineers, Calcasieu Bldg., San Antonio, are engineers.

Tex., Trinity—The City voted $42,500 bonds for the construction of a water works system, including well, reservoir, pump house, centrifugal pump, etc. F. J. Von Zuben, Ellison Blvd., F. F. Worth is engineer.

Wis., Beaver Dam—Wisconsin Power & Light Co., 16 North Carroll St., Madison, will rebuild high voltage transmission line from Beaver Dam to Horicon, including city lines, also a stepping-up station here, estimated cost $30,000. Private plans.

Wis., Crivitz—Wisconsin Public Service Corp., 559 Marshall St., Milwaukee, awarded the contract for the construction of a hydro-electric power plant, also a dam with 43 in. head, on Peshtigo River to J. R. McDonald, Black River Falls. Contract for equipment, including waterwheels, generators, etc., awarded to Allis Chalmers Mfg. Co., West Allis, estimated cost $650,000.

Wis., Milwaukee—Sewerage Comn., 508 Market St., J. H. Fowles, Secy., will receive bids Nov. 14 for conveyor system in connection with sludge handling in new filter and dryer house on Jones Island.

Ont., Acton—The City plans extensions to waterworks system, including gasoline driven 3 stage centrifugal pump about 1,000 g.p.m., estimated cost $25,000. James, Proctor & Redfern, 36 Toronto St., Toronto, are engineers.

Ont., Iroquois Falls—Abitibi Pulp & Paper Co., plans the construction of a dam and hydro electric power plant 50,000 hp. 50 ft. head, at the Long Saulte Rapids on the Abitibi River 12 miles north of Cochrane, estimated cost $4,000,000. Turbines, generators, electrical equipment, etc., will be required.

Ont., London—London Life Insurance Co., Wellington St., plans the construction of an office building including steam heating system on Dufferin St., estimated cost $500,000. J. M. Moore, 489 Richmond St., is architect.

Ont., Ottawa — Russell Hotel Co., R. Blackburn, 134 Wellington St., plans the construction of a 10 story hotel including steam heating system, elevators, etc., estimated cost $1,000,000. Architect not selected.

Ont., Port Elgin—City Council, R. McLaren, Chrm. of Comn., plans installation of auxiliary pumps and is interested in prices on electrically driven equipment.

Ont., Windsor — Essex Border Utilities Comn., Heintzman Bldg., R. B. Braid, Secy., will receive bids until Nov. 26 for the construction of a pumping station and the supply and installation of mechanical equipment. J. C. Keith, chief engineer of the comn., and Gore, Nasmith & Storrie, Confederation Life Bldg., Toronto, consulting engineers.

Ont., Windsor — E. G. Watford, 150 Sandwich St., is interested in prices on complete equipment for new artificial ice arena, estimated cost $80,000.

Que., St. Anne de Beaupre — Shrines Hotel Ltd., c/o C. A. Mitchell, Archt., 304 University St., Montreal, will soon call for bids for a hotel, estimated cost $500,000.

Que., St. Narcisse—Shawenegan Water & Power Co., Ltd., will build a concrete dam with a power house to include 2 turbines 15,000 hp. each, estimated cost $1,500,000. R. C. Lindsay, Shawenegan Falls, is engineer.